

GRAIN TRANSPORTATION IN SASKATCHEWAN

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GRAIN TRANSPORTATION IN SASKATCHEWAN

Final Report

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EXECUTIVE SUMMARY

Grain transportation policy changes are resulting in massive increases in agricultural traffic on Saskatchewan roads, as rail lines have been abandoned, elevator locations reduced and grain processing centres developed.

The Saskatchewan Association of Rural Municipalities (SARM) and Saskatchewan Highways and Transportation (DHT), in partnership with the Prairie Grain Road Program (PGRP), commissioned this study to determine the transportation infrastructure investment demand required to address the impacts of agricultural transportation resulting from *Western Grain Transportation Act* (WGTA) Reform.

The objective of the study is to evaluate the transportation infrastructure investment demand to address the impact of agricultural haul on Saskatchewan roads resulting from WGTA reform.

One of the main forces behind the increased truck haul of grain in Saskatchewan since 1985 has been the consolidation of the primary elevator system with the construction of high capacity, high throughput elevators and closure of smaller elevators. In 2003, there were 202 elevators operational, a decrease of 80% from the 1031 existing in 1985. Today, the top 50 delivery locations¹ handle 75% of grain delivered to primary elevators. During the same time frame, nearly 2,600 kilometres of rail line were abandoned while 1,269 kilometres were taken over by short line operators who handle about 2.5% of grain deliveries. The result of the elevator and rail line consolidation has been increased haul distances of grain by truck.

Livestock production has also increased dramatically since the WGTA was introduced. Hog production in 2003 was up 132% over 1985 while cattle production was up 50%. This means more trucking of feed product to these operations. Specialty (pulse) crop production has also increased rapidly from 0.3 million tonnes in 1982 to 3.7 million tonnes in 2002. This has meant increased truck traffic as these products are transported to processing facilities.

Another rapidly growing component of grain movement by truck is to processing locations; such as feed mills and feedlots, malt plants, canola crushing facilities and flour mills. There was very little of this type of truck haul in 1985. However, since the early 1990's this type of grain haul has also increased rapidly.

The number of trucks as well as total vehicle-kilometres of travel by truck has increased significantly in Saskatchewan since 1986. While overall travel on the provincial highways has increased by 27%, truck travel has grown about twice as fast as auto travel. Trucks currently account for about 20% of total travel on the Saskatchewan highway system. This growth in the number of trucks and total

¹ One location may consist of more than one elevator on one or more rail lines.

truck travel has been accompanied by the use of larger trucks with higher payloads.

Exhibit 1 indicates the change that has occurred in the size of truck used to haul grain. The eight axle B-Train, introduced in 1988, has proven to be a popular vehicle for trucking grain. These larger trucks mean that significantly fewer truck kilometres are required to deliver the same quantity of grain.

Exhibit 1: Percent of Grain Deliveries to Primary Elevators by Truck Type

Time Frame	2 - Axle	3 - Axle	5 - Axle	6 - Axle	7 - Axle	8 - Axle
Early 1970's	97 +	1-3	0-1	N/A	N/A	N/A
Late 1980's	75	18	5	0-1	0-1	2
1994	45	30	10	4	5	6
2004	35		43		22	

The evolution of truck grain haul in the province is shown by Exhibit 2. Since 1985, haul distance from the farm gate to the primary elevator has increased from 14.7 to 55 kilometres, resulting in a four-fold increase in tonne-kilometres of truck haul for this movement. Total tonne-kilometres for this type of haul are currently estimated at 810 million tonne-kilometres per annum. Truck payloads have also increased from about 5 tonnes in the 1970's to over 21 tonnes today. Other truck haul related to processing facilities, Intensive Livestock Operations (ILO's) and specialty crops now account for approximately 2.35 billion tonne-kilometres per annum. In total, grain movement by truck is over 16 times larger than it was in 1985.²

² There are other types of grain haul by truck including haul to producer loading facilities and inter-terminal haul. However, as reliable data on the magnitude of these hauls were not available, they are not included in this report. The incremental grain haul noted in this report is a conservative estimate of the increase in truck haul of grain that has occurred since 1985.

Exhibit 2: Evolution of Grain Truck Haul in Saskatchewan

Time Frame	Haul Distance Farm to Elevator (km)	Truck Average Actual Payload (tonnes)	Total Deliveries (million tonnes)	Truck Haul of Grain Farm to Elevator		Truck Haul for Processing Facilities, ILO's and Specialty Crops	
				Tonne-Km's (millions)	Loaded Vehicle-Km's (millions)	Tonne Km's (millions)	Vehicle Km's (Millions)
Early 1970's	10.3	4.8	10.4	107	20.1	Negligible	Negligible
1984/85	14.7	—	13	190	—	Negligible	Negligible
Late 1980's	16.3	10.1	15	245	24.3	Small but growing	Small but growing
Mid 1990s	23.5	11.4	19	446	39.2	1,400	—
1999*	38	—	—	—	—	—	—
2004	55	21.3	14.7	810	38.7	2,350+	50+

The impact this increased truck haul of grain has on roads varies by road type. The road types considered are structural pavements (granular and asphaltic concrete), thin membrane surfaced (TMS), gravel surfaced. Unlike structural paved surfaces, thin membrane surfaces do not improve the structural capabilities of the roadbed. Due to this limited ability to handle truck traffic, TMS roads have been of special concern when considering the impact of rail line and grain elevator consolidation on Saskatchewan's provincial road system.

Costs to accommodate the additional grain truck traffic were developed using 40-year life cycle costing procedures for structural pavements while 10 and 15 year life cycles were used for TMS and gravel surfaces respectively. Only the road component costs affected by traffic, namely road surfacing costs and summer surface maintenance costs are considered. These costs were developed on a per tonne-kilometre basis and applied to the incremental tonne-kilometres by road type to derive the road costs associated with the additional traffic

For asphalt concrete roads, the Equivalent Single Axle Load (ESAL) was used as the unit for measuring the impact of the incremental truck traffic on the roadway. This approach is the standard methodology for determining the impact of truck traffic on these types of roads and the basis on which Saskatchewan designs these highways. The ESAL approach does not apply to TMS and gravel surfaced roads as they are not structural pavements. Instead, the impact was measured using a standard weighted axle approach. Upgrading costs for TMS roads are also considered where these roads have been identified by DHT as transitional. Depending upon traffic volumes, the roads were considered to be converted to either granular pavement or gravel surfaced.

To identify the additional haulage and the roads affected due to elevator consolidation that has occurred since 1985, a traffic assignment model was developed. The model estimates the additional distance that the grain must travel in 2003/04 over 1984/85 by routing grain from the 1984/85 grain delivery points to the 2003/04 grain delivery points. It also identifies the incremental traffic by road section and hence surface type. Traffic to process facilities was estimated by road surface type from previous research work by Trimac Consultants.

A limited survey of ILO's provides an indicative estimate of the incremental traffic associated with movement of feed to these operations. Indicative estimates for haul of specialty crops are also developed. These traffic assignments were combined with the tonne-kilometre costs noted above to produce the cost estimates shown by Exhibit 3. Overall, annual ongoing road costs associated with the incremental traffic are estimated at \$89.1 million³.

Exhibit 3: Summary of Estimated Road Costs Due to Additional Haul

Haul Type	Incremental Tonne-km per Annum	Annual Cost
Farm to Primary Elevator	650,000,000	\$41,400,000
To Agro Processing Facilities	2,000,000,000	\$28,900,000
Feed for ILO's*	150,000,000	\$6,000,000
Specialty crops*	200,000,000	\$12,800,000
Total	3,000,0000	\$89,100,000

*Numbers are indicative only and to be used with caution

Three traffic scenarios for the farm to primary elevator grain movement were examined. The first scenario uses the existing road system and therefore represents the "base case". A second traffic assignment was conducted where grain haul was encouraged to use roadways designated as part of the Saskatchewan Grain Corridor System using existing truck weight limits. The third scenario used the Corridor System as well but assumed that municipal corridor roads were at primary weight limits. The Corridor System was found to divert traffic about 11% of the grain haul from the non-structural roads to structural pavements compared to the base case; however, there was not any statistically significant cost difference between the two scenarios. The third option of municipal corridors at primary weights showed a cost savings of approximately \$0.7 million per annum compared to the base case, and a savings of \$1.4 million per annum compare to the Corridor System with municipal roads at primary weights.

³ The Parallel Process on Roads report identified a cost of \$70 million (in 1999 dollars) for a 3 billion tonne kilometre scenario. This would be \$76 million in 2004 dollars (8% inflation from 1999 to 2004. Source: Corporate Support Branch), for a 16% cost difference between the two approaches.

It is noted the major benefit of identifying Corridor Systems is to strategically focus future investment and in particular avoid investment in parallel road systems in close proximity. This means the true value of the system will accrue over time as roads become candidates for resurfacing or upgrading.

It is also noted that there are additional benefits currently accruing due to the Corridor system that could not be captured in this system level analysis including:

- By concentrating traffic on specific routes, the corridor system will be a benefit on those occasions when concentrated hauls occur when TMS and gravel roadbeds have high moisture content and hence are very susceptible to damage from even a few loaded trucks. This report deals with system average costs which are not sufficiently detailed to identify these special circumstance costs.
- The level of service, in terms of ride quality, for other traffic should improve as truck traffic is removed from the gravel and TMS surfaced roads, especially under the conditions noted immediately above.
- The corridor system may negate or delay the need for future upgrading some TMS road sections off the corridor system as traffic increases. Site specific analysis beyond the scope of this project would be required to identify any such potential savings.
- Providing an aid in identification of candidate road sections for the Strategic Rural Roads Partnership Program or other similar programs.

In addition to the above system level costs which deal with road surfacing costs, there will be specific situations where other types of road improvements will be required that could not be identified by this study. One example would be where a road would need widening to accommodate the additional truck traffic. Situations will also occur in and around urban areas where new truck routes, turning lanes, wider shoulders or other improvements may need to be developed to accommodate the traffic. As well, some bridges may need strengthening or upgrading. Again, these situations would require specific on site investigations of local conditions to determine if an improvement is necessary.

1.0 INTRODUCTION

Grain transportation policy changes are resulting in massive increases in agricultural traffic on Saskatchewan roads, as rail lines have been abandoned, elevator locations reduced and grain processing centres developed.

The Saskatchewan Association of Rural Municipalities (SARM) and Saskatchewan Highways and Transportation (DHT), in partnership with the Prairie Grain Road Group (PGRP), commissioned this study to determine the transportation infrastructure investment demand required to address the impacts of agricultural transportation resulting from *Western Grain Transportation Act* (WGTA) Reform.

The objective of the study is to evaluate the transportation infrastructure investment demand to address the impact of agricultural haul on Saskatchewan roads resulting from WGTA reform. The study considers improvements completed under the Prairie Grain Roads Group (PGRP) and the Canada Agri-Infrastructure Program CAIP, as well as quantifying ongoing and increasing agricultural haul and road-use pressures.

The study identifies the investment which would be required to accommodate incremental agricultural haul while considering improvements completed by the PGRP and CAIP programs by:

- Addressing system-level road costs due to incremental (initiated by WGTA reform) haul to date, and current yearly costs;
- Determining incremental maintenance, rehabilitation, and upgrading costs by general class of road and category of improvement cost:
 - Thin Membrane Surface (TMS) roads;
 - Gravel roads; and
 - Structural pavement roads.
- Estimating the requirement for incremental long term investment to sustain strategic grain haul corridors.

2.0 GRAIN HANDLING AND DISTRIBUTION SYSTEM

The purpose of this chapter is to identify the changes in Saskatchewan's grain handling and distribution system that occurred during the study period as these changes have given rise to increased haul of grain by truck.

2.1 The Primary Elevator System

One of the main forces behind the increased truck haul of grain in Saskatchewan since 1985, when the Western Grain Transportation Act (WGTA) was implemented ending the "Crow Benefit" for rail transport of grain, has been the consolidation of the primary elevator system with the construction of high capacity, high throughput elevators and closure of smaller elevators. In 2003, there were 202 elevators operational, a decrease of 80% from the 1031 existing in 1985 as shown by Exhibit 2.1.

Exhibit 2.1: Primary Elevators in Saskatchewan and Capacity 1985 – 2003

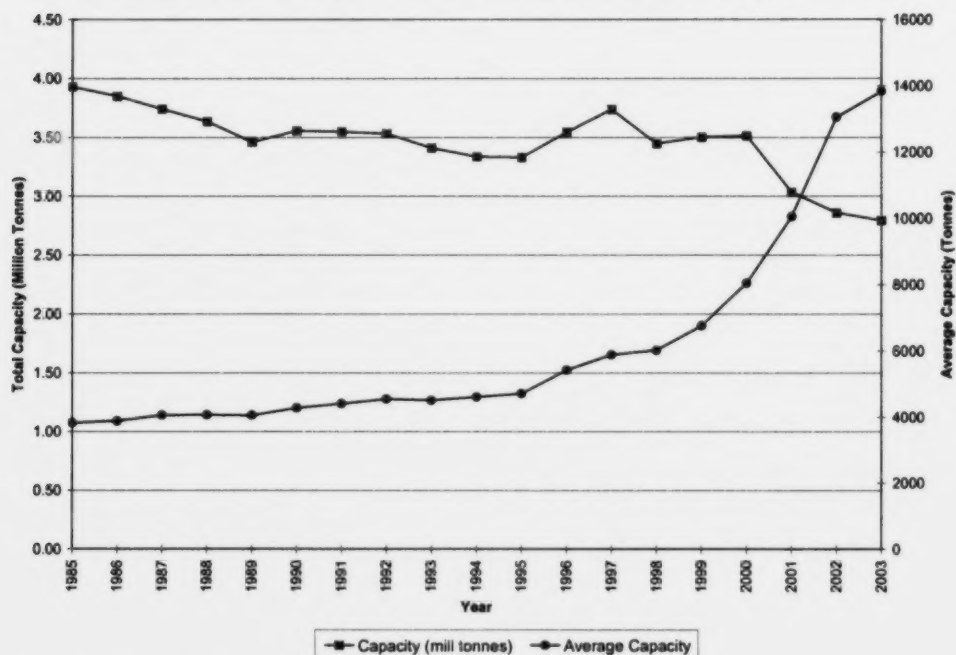
Year	Total Elevators	Total Capacity (millions tonnes)
1985	1031	3.93
1986	994	3.85
1987	925	3.74
1988	898	3.63
1989	857	3.46
1990	834	3.55
1991	807	3.55
1992	779	3.53
1993	759	3.41
1994	727	3.34
1995	709	3.33
1996	656	3.55
1997	637	3.74
1998	574	3.45
1999	519	3.50
2000	437	3.51
2001	302	3.03
2002	219	2.86
2003	202	2.79

Notes: Since 1984 the CGC allowed operators of primary elevators to licence, as a single elevator two or more adjacent facilities, which were under the control of a single manager. Data listed are as of August 1 each year. Capacity is measured in tonnes of wheat capacity.

Source: Grain Elevators in Canada (Canadian Grain Commission)

This decrease accelerated a consolidation process that had been ongoing for some time prior to 1985. While the average storage capacity increased, total capacity during the same time frame decreased by 30% as noted by Exhibit 2.2. Many of the new high throughput elevators are located on rail main lines to facilitate loading of large blocks of grain cars at a time.

Exhibit 2.2: Primary Elevators in Saskatchewan 1985 – 2003



2.2 The Rail System

2.2.1 Overall System

Saskatchewan's rail system also consolidated during the 1985 to 2004 study period as shown by Exhibit 2.3. As with elevator consolidation, rail line abandonment was occurring for some time prior to 1985. Length of track in 2004 is about 23% less than what was operated in 1985.

Exhibit 2.3: Length of Track Abandoned by Year and Railway 1985 – 2004

Year	Length of Track Abandoned (kilometres)		
	CN Rail	CP Rail	Total
1985	104.3	0.0	104.3
1986	115.5	0.0	115.5
1987	19.1	84.5	103.6
1988	2.8	7.2	10.0
1989	112.4	186.8	299.2
1990	143.7	103.2	246.9
1991	0.0	29.0	29.0
1992	66.8	40.1	106.9
1993	0.0	6.8	6.8
1994	28.1	88.7	116.8
1995	71.1	57.8	128.9
1996	254.1	222.1	476.2
1997	7.2	80.1	87.3
1998	37.7	232.1	269.8
1999	143.2	104.4	247.6
2000	28.9	0.0	28.9
2001	0.0	0.0	19.6*
2002	0.0	0.0	35.2*
2003	0.0	0.0	0.0
2004	0.0	129.4	129.4
Total Length Abandoned	1134.9	1372.2	2561.9
Total Length Operating as of December 2004	4,157.5	4,061.0	8218.5

* Length abandoned by short line railways; otherwise short line totals are not shown.

Source: Saskatchewan Highways and Transportation

2.2.2 Short Line Rail Operations

While the overall rail system was consolidating, a number of short line operations began operation. Today, a total of six short line railways operate 1,269 kilometres of track in Saskatchewan. For the 2004/2005 crop year, these rail lines handled 17,831 carloads of traffic. This includes approximately 4,200 carloads of grain, of which 2,481 were producer cars. Assuming 85 tonnes of grain per car⁴, short lines handled an estimated 357,000 tonnes of grain for the latest crop year⁵. Exhibit 2.4 provides a summary of these six lines.

⁴ Estimate provided by Canada Grain Commission staff member.

⁵ In crop year 2004/05 a total of 6,847 producer cars were loaded in Saskatchewan, handling about 500,000 tonnes of grain in total, or about 4% of deliveries to primary elevators. (Source : Canada grains Commission)

Exhibit 2.4: Short Line Rail Operations in Saskatchewan

Rail Line	Commenced Operations	Current Track Length (km)	Total cars Handled (2004/05)	Producer Cars Handled	Comments
Southern Rails Cooperative	1989	72	811	231	Only moves grain
Red Coat Road & Rail	1997	115	270	270	Only moves grain
Carleton Trail Railway	1997	481	13,521	159	Primarily moves forest products. Handles very little grain.
Great Western Rail	2000	496	2,743	1,604	Mainly moves grain
Wheatland Rail	2004	74	137	137	Only moves grain
Hudson Bay Railway		31	349	80	Bulk of traffic is alfalfa and alfalfa related products

2.3 Crop and Livestock Production

2.3.1 Grain Production

Total grain area under cultivation has remained relatively constant since the 1984/85 crop year, increasing by just 0.7% as shown by Exhibit 2.5. The major change has been a switch away from wheat to other crops, especially canola and flax. This crop switch has increased the demand for truck transportation as some of these specialty crops require longer hauls to processing locations.

Exhibit 2.5: Areas under Cultivation by Grain in Saskatchewan (Thousands of Hectares)

Grain	1975/76	1984/85	2004/05	Percent change 1984/85 to 2004/05
Wheat	5,989	6,981	4,067.1	- 42 %
Durum	1,174	1,396	1,861.6	+ 33 %
Oats	647	364	849.8	+ 133 %
Barley	1,194	1,416	1,942.5	+ 36 %
Rye	108	162	76.9	- 53 %
Flax	81	283	566.6	+ 100 %
Canola	304	1,174	2,488.8	+ 112 %
Total	9,497	11,776	11,853.3	+ 0.7 %

Source: Saskatchewan Agriculture, Food and Rural Revitalization

Exhibit 2.6 shows grain production totals by year. Annual totals vary significantly, mainly due to weather conditions. Average annual production over the 20-year time frame is 21.2 million tonnes. Exhibit 2.7 shows elevator deliveries for this time frame. Average annual amount delivered to primary elevators over the 20-year time frame 1984/85 to 2004/05 is 15.8 million tonnes, or 75% of production. The top 50 delivery locations accounted for 75% of primary elevator capacity and deliveries in 2004. Refer to Exhibit 2.8. As an option for delivery to primary elevators, producers can also load cars directly. In crop year 2004/2005 5,847 producer cars were loaded in Saskatchewan, accounting for approximately 500,000 tonnes of grain⁶.

2.3.2 Specialty (Pulse) Crops⁷

Over the past two decades, the increase in the production of specialty crops in Saskatchewan has been dramatic. Recent reports from Saskatchewan Agriculture, Food & Rural Revitalization (SAFRR) indicate that production of specialty crops reached a record 3.7 million tonnes in 2002, up from less than 0.3 million tonnes in 1982⁸. As the haul distance was not identified, and a survey of producers was beyond the budget limitations of this project, the transport requirement of this production was roughly estimated as follows. As the number of processing locations (138)⁹ is similar to the number of grain delivery points, the transport distance would seem to be the same order of magnitude as the farm to primary elevator movement of grain: 55 kilometres. Annual transport requirement is therefore roughly estimated at about 200 million tonne-kilometres¹⁰

⁶ Information provided by Canada Grain Commission. Tonnage is based on an estimated 85 tonnes per car.

⁷ Specialty crops include, as examples, lentil, chickpeas, canary seed, mustard, sunflower, caraway, and dill.

⁸ 2002 Special Crops Processors Survey Final Report. Crop Development Branch, Saskatchewan Agriculture, Food and Rural Revitalization. 2002.

⁹ From SAFRR Report.

¹⁰ 3.7 million tonnes times 55 km

**Exhibit 2.6: Production of Six Major Grains: Saskatchewan 1976 - 2004
(Thousands of Tonnes)**

Year	Wheat	Durum	Oats	Barley	Rye	Flax	Canola	Total
1976	12601	2395	1388	2961	180.2	86.4	387.8	19999.4
1977	11757	1089	1234	3723	152	271.8	839.1	19065.9
1978	11294	2313	941	2918	236.5	203	1451.5	19357
1979	8736	1470	632	1960	203.7	259.1	1281.4	14542.2
1980	9253	1687	617	2787	108.4	147.3	997.9	15597.6
1981	12002	2286	817	3331	330.1	149.9	759.8	19675.8
1982	13880	2558	956	3636	390.7	233.7	793.8	22448.2
1983	13145	2068	648	2417	348	119	1066	19811
1984	9852	1633	432	2460	229.7	224	1429	16259.7
1985	11466	1388	555	3636	205.4	310	1542	19102.4
1986	15403.7	2966.5	755.7	3940.8	261.7	396.3	1440.2	25164.9
1987	12135.6	3075.4	709.4	3919	198.1	271.8	1406.1	21715.4
1988	5497.4	1360.8	493.5	2111.9	86.4	127	1542.2	11219.2
1989	9730	3048.1	802	3135.2	408.9	236.2	1360.8	18721.2
1990	14233.6	3252.3	694	3897.3	299.7	431.8	1451.5	24260.2
1991	14881.5	3619.7	385.6	3069.9	147.3	266.7	1723.7	24094.4
1992	13633.8	2558.3	663.2	3157	109.2	109.2	1474.2	21704.9
1993	12309.6	2721.6	1079.5	4245.6	165.1	342.9	2381.4	23245.7
1994	8409.6	3701.3	1388	3919	221	546.1	3175.1	21360.1
1995	8989.4	3674.1	1110.4	4354.5	139.7	647.7	2630.8	21546.6
1996	12791.3	3755.7	1881.5	5356	134.6	472.5	2222.6	26614.2
1997	9559.5	3510.8	1403.4	4430.7	138.5	508	2698.9	22249.8
1998	7892.4	4708.3	1758.1	4310.9	152.4	680.8	3231.8	22734.7
1999	10432.1	3407.4	1534.5	4942.3	168.4	711.2	3975.7	25171.6
2000	8654.5	4757.3	1377.2	5301.6	97.8	469.9	3424.6	24082.9
2001	7374.2	2476.6	960.8	3655.6	68.6	495.3	2154.6	17185.7
2002	4545	2939.3	1048.7	2525.6	27.9	444.5	1655.6	13186.6
2003	7221.6	3211.4	1202.9	4354.5	129.5	533.4	2676.2	19329.5
2004	8314.9	3946.3	1434.3	5007.7	165.1	355.6	2903	22126.9
5yr avg (00-04)	7222.0	3466.2	1204.8	4619.0	97.8	459.7	2562.8	19182.3
10yr avg (95-04)	8577.5	3638.7	1371.2	4423.9	122.3	531.9	2757.4	21422.9
20yr avg (85-04)	10173.8	3203.9	1061.9	3963.56	166.3	417.8	2253.6	21240.9

Source: 2003 Agricultural Statistics Handbook (Saskatchewan Agriculture, Food and Rural Revitalization)

Exhibit 2.7: Elevator Deliveries by Crop Type and Year (Thousands of Tonnes)

Year	Wheat	Durum	Oats	Barley	Rye	Flax	Canola	Peas	Total
1984/1985	8,922.3	1,438.5	36.3	1,425.5	135.7	156.7	861.2		12,976.2
1985/1986	10,360.7	1,222.8	55.3	2,193.1	121.2	182.2	744.3		14,879.6
1986/1987	11,138.5	2,256.9	85.9	2,449.6	151.1	257.6	867.9		17,207.5
1987/1988	11,351.7	2,529.6	143.0	2,039.6	153.6	205.7	1,011.4		17,434.6
1988/1989	5,712.8	1,300.8	185.6	1,591.5	69.8	107.1	1,163.2		10,130.8
1989/1990	8,586.3	2,723.1	155.3	1,951.9	209.3	164.1	1,095.4		14,885.4
1990/1991	12,112.7	2,631.8	108.3	2,412.1	192.0	207.7	1,070.0		18,734.6
1991/1992	12,368.7	2,773.2	88.5	1,867.7	129.6	183.4	1,140.7		18,551.8
1992/1993	11,642.0	2,124.2	240.2	1,920.7	106.3	116.9	1,116.5		17,266.8
1993/1994	10,318.3	2,757.5	486.3	2,478.5	80.8	267.1	1,736.4		18,124.9
1994/1995	8,278.7	3,422.8	705.6	2,674.4	122.1	401.9	2,130.5		17,736.0
1995/1996	7,169.9	3,024.6	511.8	2,790.4	97.0	495.2	1,783.3		15,872.2
1996/1997	10,235.7	3,222.0	933.6	3,281.5	61.5	334.8	1,549.5		19,618.6
1997/1998	8,550.3	3,094.0	660.9	2,576.9	56.5	459.4	2,083.7		17,481.7
1998/1999	5,966.0	3,737.9	741.6	2,133.6	34.2	503.7	2,384.5		15,501.5
1999/2000	8,167.6	2,968.1	737.8	2,475.4	42.4	480.7	2,544.6		17,416.6
2000/2001	6,655.4	3,145.2	784.9	2,829.7		375.3	2,844.4	825.4	17,460.3
2001/2002	6,030.8	2,536.7	625.7	1,892.8		398.0	1,434.8	311.2	13,230.0
2002/2003	3,425.0	2,433.4	335.6	1,079.2		341.0	1,289.2	207.2	9,110.6
2003/2004	5,532.8	2,209.6	493.4	2,304.5		384.7	1,880.2	644.7	13,449.9
20-year Average									15,853

Source: Canada Grain Commission

Exhibit 2.8: Primary Elevator Top 50 Delivery Points 2004

Location	Capacity (tonnes)	Total Station Deliveries (000's tonnes)	Location	Capacity (tonnes)	Total Station Deliveries (000's tonnes)
Saskatoon	164.5	611.7	Fairlight	25.3	156.1
Weyburn	169.8	520.0	Booth Siding	25.8	155.8
Melfort	66.5	441.0	Hamlin	28.4	155.3
Moose Jaw	177.5	415.1	Foam Lake	19.4	150.9
Canora	35.5	363.3	Camduff	30.1	150.8
Tisdale	61.1	359.3	Congress	31.7	150.4
Swift Current	75.4	338.8	Corinne	48.8	149.3
Unity	94.0	302.8	Brada	48.8	143.6
Kindersley	76.6	291.5	Moosomin	25.5	138.6
Yorkton	62.0	291.4	Grenfell	20.1	137.2
Rosetown	78.9	257.7	Marshall	22.5	133.2
Gull Lake	71.0	252.3	Melville	19.0	131.7
Davidson	36.5	251.1	Loreburn	17.0	130.9
Wadena	44.9	249.0	Whitewood	20.6	128.2
Dixon	21.5	232.0	Nokomis	31.5	126.9
Valparaiso	30.4	223.3	Last Mountains	17.1	125.1
Balgonie	42.9	203.1	Reed Lake	18.0	122.4
Aberdeen	30.6	192.3	Kegworth	31.3	117.5
Humboldt	26.0	184.6	Ituna	18.6	115.7
Kamsack	14.9	178.5	Lloydminster	15.0	109.0
Assiniboia	45.8	175.7	Prairie West	31.7	102.5
Clavet	21.0	172.7	Amazon	23.8	100.2
Carrot River	27.3	163.6	Regina East	31.5	99.8
Balcarres	32.5	163.1	Leader	17.1	95.0
Naicam	23.3	159.0	Luseland	16.1	92.6
Totals				2,165.1	10,211.6

Source: Based on individual elevator delivery data from Canada Grain Commission

2.3.2 Livestock Marketed

Due to changes brought about by the WGTA, livestock production in the province has increased significantly. In fact, the number of cattle marketed in recent years is about 50% higher than it was in 1985, while the number of hogs marketed is up 132%. Refer to Exhibit 2.9. The road impacts of this increased production are estimated in Chapter 10.

Exhibit 2.9 Livestock Marketed in Saskatchewan (number of head)

Year	Cattle	Calves	Hogs	Sheep
1985	n.a.	n.a.	843,703	10,850
1986	n.a.	n.a.	759,592	8,693
1987	806,730	276,900	839,179	7,886
1988	871,080	257,370	1,050,650	6,045
1989	850,020	250,180	1,107,462	6,957
1990	840,740	254,420	1,001,565	8,747
1991	787,340	239,240	1,029,272	8,897
1992	890,270	278,770	1,109,475	11,994
1993	985,860	280,070	1,118,065	11,965
1994	939,270	261,960	1,131,996	9,798
1995	977,800	231,660	1,186,232	8,556
1996	1,049,070	249,940	1,121,786	9,361
1997	1,052,590	335,810	1,038,545	8,565
1998	968,880	291,520	1,116,463	7,816
1999	1,102,480	316,300	1,261,026	8,672
2000	1,104,340	323,720	1,488,438	n.a.
2001	1,148,000	356,450	1,677,644	n.a.
2002	1,327,790	416,940	1,890,530	n.a.
2003	1,207,290	321,970	1,956,477	n.a.
Percent Change 1987 to 2003	+ 50 %	+ 16 %*	+ 132 %	n.a.

*Increases to 50% if 2002 numbers are used.

Source: Saskatchewan Agriculture, Food and Rural Revitalization – Cattle Marketing, SPI Marketing Group.

3.0 THE ROAD SYSTEM

3.1 Length and Type

Saskatchewan has over 185,000 kilometres of provincial highways and rural municipal roads. The highway system for which the Provincial Department of Highways and Transportation is responsible is just over 26,000 kilometres in length. Of this total, 35% is asphaltic concrete, 25% is thin membrane surfaced and 19% granular pavement¹¹. The remainder is gravel.

The municipal road system in Saskatchewan consists of just over 160,000 kilometres of road. The majority are gravel roads. Only 0.4% of roads are constructed to a structural pavement while just less than 0.6% having a thin membrane surface.

Thin membrane surface (TMS) were first used on secondary highways in the province during the 1950's. Unlike structural paved surfaces, thin membrane surfaces were not meant to improve the structural capabilities of the roadbed. They were built to provide a dust, mud and stone free driving surface at a much lower construction and maintenance cost than structural pavements. As public demand for dust free roads grew during the 1960's and 1970's the use of thin membrane surfaces increased dramatically. Today, truck traffic volumes have reached the level where many TMS surfaces have difficulty performing adequately even with maximum maintenance efforts. Construction of these roads was discontinued in the early 1980's.

Most gravel surfaced roads in the province only have a light covering of surface gravel, mainly to improve traction. The gravel does not add significantly to the structural capability of the roadbed, unlike in other provinces where the gravel may be 15 cm or more in thickness and hence provide structural support similar to a structural pavement.

Due to their limited ability to handle truck traffic, TMS roads are of prime concern when considering the impact of rail line and grain elevator consolidation on Saskatchewan's provincial road system.

3.2 Road Improvement Programs

Programs that have been made available to fund improvements on roadways affected by grain haul include:

- The Prairie Grain Roads Program (PGRP) is a five-year, \$175 million federal program established to improve municipal roads and provincial secondary highways used for grain transportation in Manitoba,

¹¹ Refer to Appendix 1 for an illustration of each road type

Saskatchewan, Alberta and the Peace River District of British Columbia. A total of 1,700 kilometres of road (1,150 kilometres municipal and 600 kilometres highway) have been improved under this program in Saskatchewan by year end 2004..

- In 1996, prior to PGRP, the Canada Agri-Infrastructure Program (CAIP) was initiated under the Western Grain Transportation Adjustment Fund (WGTA) to invest in agricultural infrastructure which could be affected by the termination of subsidies under the Western Grain Transportation Act (WGTA). This program provided \$140 million to Manitoba, Saskatchewan, Alberta, and British Columbia. The funding for this program was allocated based on the miles of grain dependent branch lines. Saskatchewan's share was \$84.6 million for highways and municipal roads. The program was later expanded to include short line railways and transportation planning studies. A total of 2,000 kilometres of road (1,700 kilometres municipal and 300 kilometres highway) have been improved under this program in Saskatchewan.

PGRP will partner with Saskatchewan Highways and Transportation, and municipalities to improve municipal roadways through the Strategic Rural Roads Partnership Program. This program allows DHT to work with municipalities to allow road users to utilize municipal roads for heavy haul (in areas where provincial highways don't have adequate pavement structure). To date, the program has been used to create alternative haul routes for 435 km of roadway; which includes many PGRP projects.

4.0 EVOLUTION OF TRUCK TYPES AND TRAFFIC PATTERNS

4.1 Truck Travel

The number of trucks as well as total vehicle-kilometres of travel by truck has increased significantly in Saskatchewan since 1986 as indicated by Exhibit 4.1. While overall travel on the provincial highways has increased by 27%, truck travel has grown about twice as fast as auto travel¹². Trucks currently account for about 20% of total travel on the Saskatchewan highway system.

Exhibit 4.1 Travel on Saskatchewan Highways for Selected Years

Vehicle Type	Vehicle Kilometres of Travel (millions)		Percent change
	1986	2004	
Provincial Roads			
• All Vehicles	6,015	7,660	27 %
• Trucks Only*	795	1,418	78 %
• Percent Truck Travel	13.2 %	18.5 %	
Rural Municipal Roads			
• All Vehicles	1,801	2,194	22 %
• Trucks Only	Not available	470	---
• Percent Truck Travel	Not available	21.4 %	---

*Commercial Trucks Classes 5 to 13

Source: Saskatchewan Highways and Transportation

This growth in the number of trucks and total truck travel has been accompanied by the use of larger trucks with higher payloads¹³. As discussed below, this has occurred throughout the entire highway system, both provincial and municipal.

4.2 Evolution of Maximum Gross Vehicle Weights

4.2.1 Provincial Highway System

Exhibit 4.2 shows the maximum allowable gross vehicle weight (GVW) by the most common truck types since the 1970's. The maximum GVW has increased substantially over time allowing for considerably larger payloads.

¹² The accuracy of truck counts has improved in recent years with the use of current generation traffic classifiers. Traffic Section officials note that the truck traffic volumes published for the 1980's are underestimated by about 10% to 20%. This would mean truck traffic volumes have increased 50% to 60% since 1986 rather than the 78% noted by Exhibit 4.1. The comment that truck traffic has increased about twice as fast as auto travel takes this underestimation into account.

¹³ This has been accomplished mainly through the use of additional axles, mainly in the form of tri-axle groups. Per tonne of freight carried these trucks cause less damage to structural pavements than trucks with tandem axle groups.

The last major increase in GVW for the provincial highway system came in 1988, under the National Memorandum of Understanding on Vehicle Weights and Dimensions agreed to by the provincial and federal transport ministers. Under this agreement, GVW was increased on tractor-trailer combinations by allowing additional weight on tri-axle groups. This meant the introduction of the 6-axle tractor-trailer and the 8-axle B-train, which are well suited to carrying higher density and bulk commodities. Today, both of these vehicle types are used extensively to haul grain. Exhibit 4.2 also indicates the most recent GVW limits on secondary highways. These are generally less than the primary highways in recognition of the lower structural capability of secondary highways.

**Exhibit 4.2: Maximum Allowable Gross Vehicle Weight
Provincial Highway System (Kilograms)**

Vehicle Type	Primary Highways				Secondary Highways
	1974-1982	1982-1988	1988-1999	1999 to present	1988 to Present
2-axle straight	14,600	14,600	14,600	16,350	13,700
3-axle straight	21,326	22,500	22,500	24,250	20,000
5-axle tractor trailer	37,273	39,500	39,500	39,500	34,500
6-axle tractor trailer	37,273	39,500	46,500	46,500	40,000
8-axle B-Train	50,000	53,500	62,500	62,500	54,500

4.2.2 Municipal System

The Rural Municipalities Act of May 1981 resulted in uniform weight regulations applying to all municipal roads. Prior to this date each RM could set its own limits. As noted by Exhibit 4.3, changes were made in 1992 to bring the GVW of the 6-axle tractor-trailer and the 8-axle B-train to those of the secondary highway system. This was done to facilitate movement between the municipal system and the secondary provincial system as many trips on the secondary system also use the municipal system for a portion of the trip.

**Exhibit 4.3: Maximum Allowable Gross Vehicle Weight Limits
Municipal Roads (Kilograms)**

Truck Type	1981-1991	1992- Present
2-axle straight	13,700	13,700
3-axle straight	20,000	20,000
5-axle tractor trailer	34,500	34,500
6-axle tractor trailer	34,500	40,000
8-axle B-Train	34,500	54,500

The Highway Traffic Act 1999 gave urban and rural municipalities flexibility to restrict weights as well as designate primary weights (or higher). This allows truck traffic to be switched to roads that are more capable of handling the truck traffic.

5.0 CHANGES IN USE OF TRUCK TYPES

5.1 Truck Types on Provincial Roads

The usage of the larger vehicle types increased as higher gross vehicle weight limits made these vehicles more economical to operate. Exhibit 5.1 indicates how this frequency of use has changed over time. Clearly, there has been a major shift away from the 2-axle straight truck to the 5-axle tractor semi-trailer and trucks with more than 5-axes. The use of 6-plus axle vehicles has increased dramatically since the mid-1980's when additional weight allowances made these vehicles more popular. These vehicles are used primarily to move heavy commodities, such as grain, that take advantage of the higher allowable weights. This makes longer haul distances more economical.

Exhibit 5.1: Percent Distribution of Truck Type on Provincial Highways

Truck Type	Year				
	1975	1981	1986	1995	2004
2-axle Straight	48.4	35.3	32.0	20.0	14.4
3- axle Straight	10.1	13.5	12.0	10.0	12.3
5- axle Semi-Trailer	33.3	40.4	30.4	29.2	25.5
Other	8.2	10.4	25.6	40.8*	47.8**

Years 1975 to 1995 are based on data gathered at portable weigh scale sites. 2004 is based on vehicle classification data by road control section.

* Includes 16.3% B-Trains, 11.3% six-axle tractor semi-trailers, 13.2% other

**Includes 15.9% 7plus-axle multi-trailers, 16.5% six-axle tractor semi-trailer and 15.4% other

5.2 Truck Types on Municipal Roads

The Department of Highways and Transportation collects vehicle classification and volume data for the RMs on rural municipal roads. These data were used to show trends in truck types travelling on municipal roads as shown by Exhibit 5.2. Similar to provincial roads, the results clearly show the decline in the use of 2, 3 and 5 axle trucks in favour of 5 plus axle trucks; including 6 axle semis and B-trains.

Exhibit 5.2: Percent Distribution of Truck Types on Municipal Roads (by number of trucks)

Truck Type	1989	1999-2004*
2-axle	57 %	40 %
3-axle	15 %	13 %
5-axle	17 %	11 %
5+ axle	3 %	27 %
Other	8 %	9 %

*Approximately 20% of RM's are surveyed each year. This time frame includes 5 years data thereby covering the entire RM system.

Sources: ADI Limited; A methodology for Measuring the Impact of Branchline Abandonment on Provincial and Municipal Roads in Saskatchewan. Prepared for Saskatchewan Highways and Transportation and Transport Canada, 1989. Department of Highways and Transportation 1999-2004.

6.0 EVOLUTION OF GRAIN HAUL BY TRUCK

6.1 Truck Size and Haul

Exhibit 6.1 indicates the changes over time in the split of the vehicle types used to deliver grain. In particular, the use of tractor semi-trailers and double trailer combinations for grain haul increased dramatically in the more recent years. By 1994 these vehicles accounted for about 25% of farm to elevator movement of grain in Saskatchewan. Today they account for about 65%.

Exhibit 6.1: Percent of Grain Deliveries to Primary Elevators by Truck Type

Time Frame	2 – Axle	3 – Axle	5 – Axle	6 – Axle	7 – Axle	8 – Axle
Early 1970's	97 +	1-3	0-1	N/A	N/A	N/A
Late 1980's	75	18	5	0-1	0-1	2
1994	45	30	10	4	5	6
2004	35		43		22	

References: ADI 1989; Sask Hwys 1994 and 2004 Grain Truck Weight Studies, Compliance Branch.

Not only have truck sizes increased significantly over the past 20 years; so has the average haul distance. It is estimated the farm gate to elevator movement of grain has increased over 300% since 1984/85, as measured by tonne-kilometres. There has also been a huge increase in the truck haul of grain to process locations, specialty crops and ILO's as shown by Exhibit 6.2. More information on these movements is presented in Chapter 7. In total, truck movement of grain, as measured by tonne-kilometres, is now estimated to be over 16 times greater than it was in 1985.

Exhibit 6.2: Evolution of Grain Truck Haul in Saskatchewan

Time Frame	Haul Distance Farm to Elevator (km)	Truck Average Actual Payload (tonnes)	Total Deliveries (million tonnes)	Truck Haul of Grain Farm to Elevator		Truck Haul for Processing Facilities, ILO's and Specialty Crops	
				Tonne-Km's (millions)	Loaded Vehicle-Km's (millions)	Tonne Km's (millions)	Vehicle Km's (Millions)
Early 1970's	10.3	4.8	10.4	107	20.1	Negligible	Negligible
1984/85	14.7	--	13	190	--	Negligible	Negligible
Late 1980's	16.3	10.1	15	245	24.3	Small but growing	Small but growing
Mid 1990s	23.5	11.4	19	446	39.2	--	--
1999*	38	--	--	--	--	--	--
2004	55	21.3	14.7	810	38.7	2,350+	50+

Sources: ADI 1989; Barton, 1998 (Grain Truck Haul and Saskatchewan Roads, prepared for SHT), SHT producer survey, 1999; SHT Saskatchewan Grain Flow Model Version 2004 (Wayne Gienow). 1985 estimated by interpolation between 1973 and 1988 estimates (from ADI 1988) based on number of elevators closed between those years.

6.2 Grain as a Percentage of Total Truck Haul

The portion of truck travel in the province that is grain haul varies depending upon the function of the highway and its location vis-à-vis grain production and grain delivery points. Recent origin-destination surveys conducted by the Department of Highways and Transportation provide an indication of the level of grain haul on the highway system where the survey stations were located. Unfortunately, there are not any estimates of this traffic prior to 1993. Exhibit 6.3 provides a summary. Both grain and livestock traffic has increased as a percentage of the total truck traffic.

Exhibit 6.3: Estimated Grain Haul on Primary Highways

Year	1993	1997	2003
Percent Total Truck Traffic	6.0 %	7.0 %	8.8 %
Truck Type Distribution	Straight 44 %	Straight 12 %	Straight 6 %
	Single trailer 16 %	Single trailer 27 %	Single trailer 30 %
	Multi trailer 40 %	Multi trailer 61 %*	Multi trailer 64 %*
Livestock & Grain as Percent of Total Truck Traffic on Primary Highway System	7.9 %	7.1 %	10.0 %

Source: SHT Axle Weight and Commodity Survey for year indicated.

* Majority are B-trains

7.0 AGRO PROCESSING GRAIN HAUL

In addition to increased truck haul to from the farm to the primary elevator, a growing component of grain movement by truck is to processing locations, including:

- Feed mills and feedlots;
- Malt plants;
- Canola crushing facilities;
- Flour mills;
- Distillers; and
- Other processors.

There was very little of this type of truck haul in 1985. However, since the early 1990's this type of grain haul has increased rapidly. The magnitude of this movement was estimated in 1999 by Trimac¹⁴. As the original report had totals for the Prairie Provinces as a group, the data were analyzed to provide information for Saskatchewan only as shown by Exhibit 7.1. In 1999, the movement of grain to process locations is estimated at 1.7 million tonne-km. This includes all movements on Saskatchewan roads, including the Saskatchewan portion of interprovincial movements.

¹⁴ Trimac Consulting Services Limited. Truck Traffic Changes in Grain Transportation. Prepared for Transport Canada, 1999.

Exhibit 7.1: Agrofood Processing and Feed Movements for Saskatchewan

Product	Collection (Plant) Location	Total Tonnes	Tonnes On Sask Roads	Sask Roads Tonne-KM	Sask Roads Truck-KM	Avg. Sask Dist.
Wheat	Calgary, AB	198,799	16,997	2,518,206	59,252	148.2
Wheat	Elie, MB	40,541	3,092	621,675	14,628	201.1
Wheat	Lethbridge, AB	84,650	58,888	29,649,514	697,636	503.5
Wheat	Medicine Hat, AB	115,057	93,143	41,459,113	975,509	445.1
Wheat	Saskatoon, SK	177,917	177,917	40,743,782	958,677	229.0
Wheat	Winnipeg, MB	53,011	10,964	2,564,256	60,335	233.9
Wheat	Humboldt, SK	3,092	3,092	621,675	14,628	201.1
Total/Wtd. Avg.	All Wheat Locs.	673,067	364,093	118,178,221	2,780,665	324.6
Barley	Biggar, SK	211,982	211,982	55,175,480	1,298,247	260.3
Barley	Calgary, AB	221,091	22,159	7,913,558	186,201	357.1
Barley	Winnipeg, MB	85,498	14,971	983,382	23,138	65.7
Total/Wtd. Avg.	All Barley Locs.	518,571	249,112	64,072,420	1,507,586	257.2
Canola	Altona, MB	268,571	109,142	24,687,344	580,878	226.2
Canola	Clavet, SK	497,013	479,013	106,894,191	2,515,157	223.2
Canola	Harrowby, MB	348,526	196,384	31,412,543	739,119	160.0
Canola	Lethbridge, AB	247,555	4,798	399,123	9,391	83.2
Canola	Lloydminster, AB	495,534	12,265	358,549	8,436	29.2
Canola	Nipawin, SK	247,965	247,965	43,120,751	1,014,606	173.9
Canola	Ste. Agatha, MB	249,072	123,652	37,695,891	886,962	304.9
Total/Wtd. Avg.	All Canola Locs.	2,354,236	1,173,219	244,568,392	5,754,549	208.5
Durum	Lethbridge, AB	58,918	28,934	12,990,656	305,662	449.0
Durum	Saskatoon, SK	68,582	68,582	18,276,039	430,024	266.5
Total/Wtd. Avg.	All Durum Locs.	127,500	97,516	31,266,695	735,686	320.6
Rye (Distillery)	Calgary, AB	46,939	17,004	2,581,572	60,743	151.8
Rye (Distillery)	Lethbridge, AB	33,290	31,081	6,043,280	142,195	194.4
Rye (Distillery)	Gimli, MB	51,912	23,102	3,982,707	93,711	172.4
Total/Wtd. Avg.	All Rye to Distillers	132,141	71,187	12,607,559	296,649	177.1
Oats	Dalmeny, SK	96,924	96,924	18,919,285	445,160	195.2
Oats	Saskatoon, SK	44,925	44,925	10,395,774	244,606	231.4
Oats	Yorkton, SK	23,631	23,631	2,364,646	55,639	100.1
Oats	Portage la Prairie, MB	96,779	38,671	4,453,308	104,784	112.3
Total/Wtd. Avg.	All Oats to Proc.	262,259	205,151	36,133,013	850,189	176.1
Feed Grains	Arborg, MB	157,949	138,052	61,481,164	1,446,616	445.3
Feed Grains	Brooks, AB	467,011	361,269	140,143,921	3,297,504	387.9
Feed Grains	Coaldale, AB	1,634,727	1,309,184	611,094,881	14,378,703	466.8
Feed Grains	Fisher Branch, MB	128,445	94,531	38,114,756	896,818	403.2
Feed Grains	Gregg, MB	67,934	30,341	8,414,089	197,979	277.3
Feed Grains	Maple Creek, SK	65,875	65,875	29,471,484	693,447	447.4
Feed Grains	Provost, AB	244,962	244,962	100,992,834	2,376,302	412.3
Feed Grains	Ste. Anne, MB	894,017	660,846	227,494,189	5,352,804	344.2
Total/Wtd. Avg.	All Feeds (Non Local)	3,660,820	2,905,060	1,217,207,318	28,640,173	419.3
	All Agro Processing	7,728,694	5,065,338	1,724,033,618	40,565,468	340.4

The study team consulted several sources to determine if any information existed to update this estimate to 2004. Contacts included federal and provincial agricultural officials as well as agricultural consultants and researchers. Websites of process plants were also investigated. Unfortunately, no up to date estimates of changes since 1999 were identified. The processing companies contacted indicated that they considered their production data confidential and therefore not available to the consultant.

Due to the limitations on data sources noted above, the study team used the best available indicator on each processing sector to update the changes in use of grain by that sector since 1999. For example, flour milling was indicated to be a mature industry in a consolidation mode with little or no actual growth. Cattle and hog production were obviously in an expansion mode with processing plants noting recent or planned expansions on their websites. This is in keeping with the growing number of animals being marketed each year. These results by sector were then combined to determine an overall growth estimate for agro-processing. Exhibit 7.2 summarizes the results.

Results, which must be taken as preliminary in nature, indicate grain usage by agro-processing is up by 17% since 1998. Applying this same growth to the grain haul estimate yields a total agro-processing haul of 2 billion tonne-km per annum.

**Exhibit 7.2: Estimated Growth in Agro-Processing Traffic
in Saskatchewan Since 1999**

Item	Tonnes of Grain Used in 1998*	Estimated Usage for 2004	2004 Status Compared to 1998
Flour Milling	676,250	676,250	Mature market; about the same production levels; assume no change.
Durum Milling	127,500	127,500	Same as for flour milling; no change.
Oat Crushing	380,500	380,500	Saskatchewan Oat production levels same as 1998 or slightly lower; assume no change***
Oil Seed Crushing	2,518,750	2,518,750	Saskatchewan Canola production levels same as 1998 or slightly lower; assume no change***
Wheat & Barley Fractionation	692,500	692,500	Small portion of overall grain used by agro-processing; assume no change.
Corn & Rye Distillation	137,500	137,500	Small portion of overall grain used by agro-processing; assume no change.
Malt Barley	607,250	607,250	Small portion of overall grain used by agro-processing; assume no change.
Cattle Feeding**	3,024,000	3,749,760	Cattle marketed up 24%; assume grain usage up same amount. (Refer to Exhibit 2.8)
Hog Feeding**	1,201,000	2,101,750	Hogs marketed up 75%; assume grain usage up same amount. (Refer to Exhibit 2.8)
Total Estimated Usage	9,365,250	10,991,760	
Increase 2004 over 1998		17%	

* Source: Prairie provinces totals presented in Columns 2 and 3 are from Trimac Consulting Ltd. (Note: Totals may not exactly match those shown in Exhibit 7.1 due to minor differences in breakdown of numbers). Growth factors presented in column 4 are for Saskatchewan only.

** At slaughter houses.

*** Weather conditions limited crop production in recent years; otherwise growth may have occurred.

The available information from the Trimac report on roads was used to estimate the road costs associated with this haul, which are provided in Exhibit 10.4. For purposes of this report, the following costs have been assumed: \$0.0076 per tonne-km for primary highways as most of the distance traveled would be on the higher strength asphalt pavements; \$0.0525 for secondary roads representing a blend of costs for TMS, gravel and lower strength asphalt pavements¹⁵; and \$0.0378 for gravel roads. A traffic assignment model, which was beyond the resources and time available for this study, would be required to prepare a more rigorous cost estimate.

Trimac¹⁶ found the hopper bottomed 8-axle Super B-Train to be the most popular vehicle for this type of movement, accounting for about 85% of the movement. The majority of this traffic was reported to be occurring on primary highways as shown by Exhibit 7.3.

Exhibit 7.3: Agro Processing Grain Haul by Road Type

Road Type	Percent Distance Traveled
Primary Highway	68.7
Secondary Highway	22.3
Local Gravel Road	9.0

Applying the route type distribution shown to the total estimated agro processing haul provides the following estimate of haul by route type (Exhibit 7.4).

Exhibit 7.4: Estimated Agro Processing Haul by Road Type

Road Type*	Distance Traveled (millions tonne-kms)
Primary Highway	1,184
Secondary Highway	385
Local Gravel Road	155

* Road type was designated by the hauler interviewed and does not necessarily correspond to the classification system previously used by DHT that employed the same nomenclature.

¹⁵ The costs used to calculate this average are \$0.0378 for gravel roads; \$0.0348 for asphalt concrete (average cost for 1 to 4 million ESAL range) and \$0.0679 for TMS.

¹⁶ Trimac Consulting Services Ltd., Review of Grain Transportation by Truck in Western Canada. Prepared for Transport Canada, 1997.

In addition to the truck haul to grain processing facilities as noted above and the farm to primary elevator truck haul of grain covered by this report, there are other types of grain haul by truck including producer loading facilities¹⁷ and inter-terminal haul. Unfortunately, reliable data on the magnitude and/or delivery patterns of these hauls were not available and hence they are not included in this report. This means the incremental grain haul noted in this report is a conservative estimate of the increase in truck haul of grain occurring since 1985.

¹⁷ While producer haul is estimated at 500,000 tonnes a year (refer to section 2.3.1) information on delivery patterns is not available. As a consequence this traffic could not be included in the road impact portion of the analysis.

8.0 PRIMARY ELEVATOR GRAIN HAUL ASSIGNMENT PROCEDURE

8.1 Grain Haul Forecasting Methodology

A grain haul assignment model was developed to estimate the incremental increase in grain tonnage on the Saskatchewan road network from 1985 to 2004 as a result of grain closures and elevator consolidation resulting from the Western Grain Transportation Act (WGTA) Reform. The model is based on a modified version of the traditional four-step urban transportation planning procedure. The mode split step is not required as only one mode of transport, truck haul, is being analyzed. The grain haul assignment model is therefore comprised of three steps: grain haul generation, grain haul distribution and grain haul assignment.

In 1984/85, grain traveled from an origin farm to one of 588 possible grain delivery points. In comparison, grain in 2003/04 was delivered to just 133 grain delivery points (or terminals). This reduction of 455 possible grain delivery locations means that most grain shipments must travel farther to access a delivery point in 2003/04 than they did in 1984/85. The grain haul assignment model estimates the additional distance that the grain must travel in 2003/04 over 1984/85 by routing grain from the 1984/85 grain delivery points to the 2003/04 grain delivery points. This procedure is based on the assumption that all grain delivery points are located on fairly major roads and therefore, after closure of a particular grain delivery point, the additional grain haul distance would be from the closed delivery 1984/85 point to the new 2003/04 delivery point along the provincial/municipal arterial/collector system.

TransCAD Transportation GIS Software was used in the development of the model. TransCAD Version 4.7, a geographic information system (GIS) developed by Caliper Corporation, is primarily used for planning, managing, and analyzing the characteristics of transportation systems and facilities. Numerous transportation planning procedures are included as part of TransCAD software, including four-step demand models and an extensive set of traffic assignment models. TransCAD modeling procedures can be used for urban or regional demand forecasting, as well as modeling passenger and freight flows at the provincial, national and international level.

8.2 Grain Haul Generation

The first step in the grain haul assignment model is the grain haul generation. Grain haul generation estimates the volume and location of grain originating and delivered within Saskatchewan. Grain haul generation is comprised of two components; grain haul production and grain haul attraction. For the grain haul assignment model, grain haul is "produced", or originates, at the 1984/85 grain delivery points and is "attracted", or delivered, to the 2003/04 grain delivery points.

Grain delivery locations for the 1984/85 and 2003/04 crop years were obtained from the Canadian Grain Commission and provided by Saskatchewan Highways and Transportation and are illustrated in Exhibit 8.1. A total of 588 grain delivery points received grain in the 1984/85 crop year and 133 grain delivery points received grain during the 2003/04 crop year. Multiple grain elevators can be located at a single delivery point. Grain delivery volumes at the 2003/04 grain delivery points used in the model were based on a five year average of deliveries at current delivery points. An average of delivered tonnages was used instead of a single year of delivery information to balance out any irregularities that might occur during a single crop year and influence the delivered tonnage data, such as a drought.

For the purpose of the grain haul assignment model, total grain originating at the 1984/85 grain delivery points must equal the total grain delivered to the 2003/04 grain delivery points. The total delivered tonnage to the 2003/04 grain delivery points (a five year average of 14.1 million tonnes) was distributed to the 1984/85 grain delivery points using the percent deliveries at 1984/85 grain delivery points.

8.3 Grain Haul Distribution

The purpose of the grain haul distribution component of the model is to estimate the grain tonnage moving between origin-destination pairs¹⁸. The result of the grain haul distribution process is a matrix that identifies the origins (1983/84 grain delivery points) and destinations (2003/04 grain delivery points) of all grain haul movements.

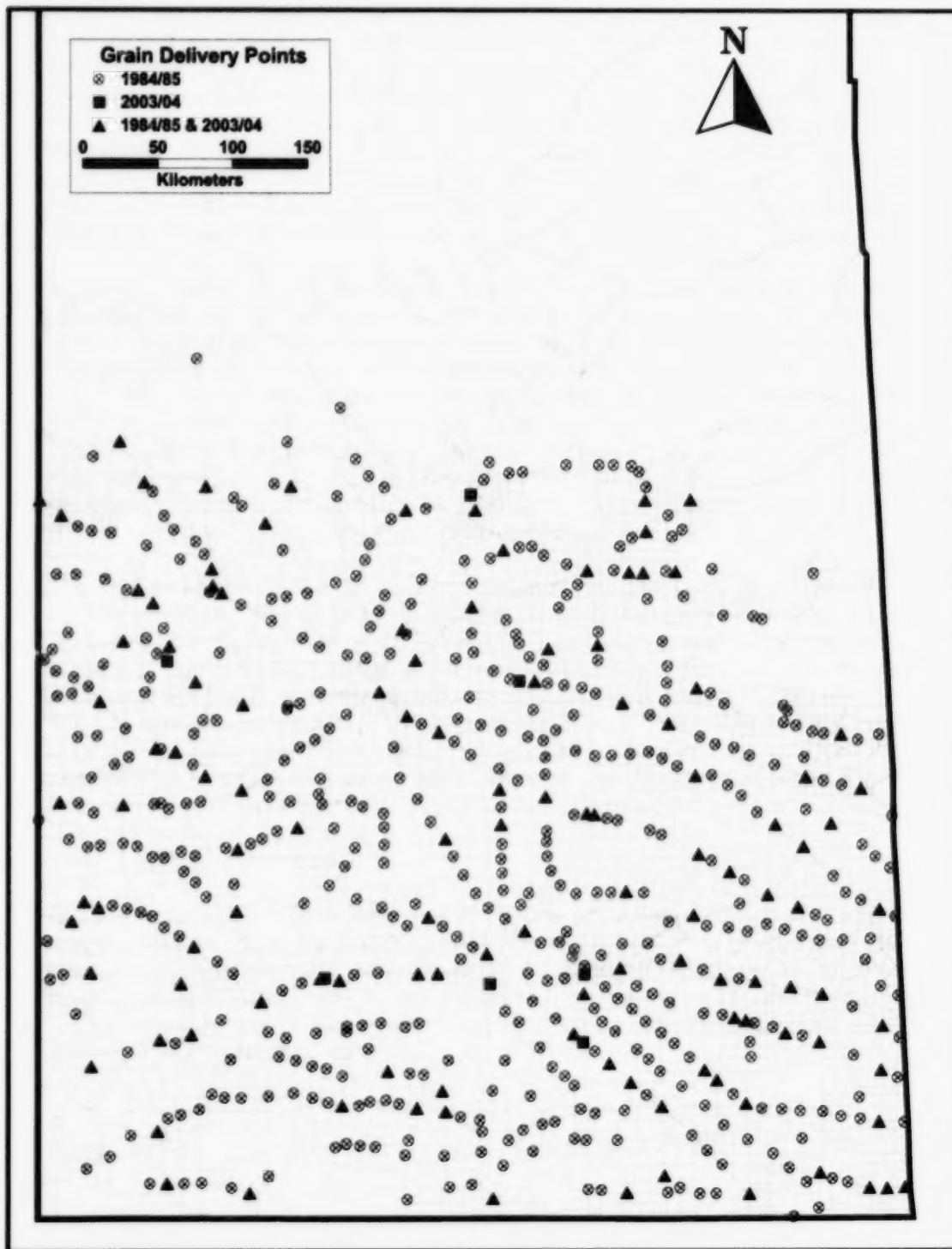
The gravity model is used in the majority of regional freight distribution initiatives¹⁹ and was therefore used to determine grain haul distribution in Saskatchewan. The gravity model assumes that grain haul movement between two locations is directly proportional to the amount of grain production and attraction at each location and inversely proportional to the impedance between the two locations²⁰. Several different measures of impedance can be used for forecasting grain haul movements, including transport distance, transport time, and transport cost. Transport distance is readily available and was used as the measure of impedance for the grain haul distribution component.

¹⁸ Goulias, Konstadinos G. and JinKi Eon, *Centre County Simulation (CentreSIM): Incorporating Truck Traffic and Improvement Network Data*. Pennsylvania State University, 2003.

¹⁹ Mao, Shaohui and Dr. Michael J. Demetsky, *Calibration of the Gravity Model for Truck Freight Flow Distribution*. Mid-Atlantic Universities Transportation Centre, Centre for Transportation Studies, University of Virginia, 2002.

²⁰ Huang, Wen-Jing, *Development of Statewide Truck Travel Demand Models Using Multiple Data Sources*. University of Wisconsin-Madison, 1998.

Exhibit 8.1: 1984/85 & 2003/04 Saskatchewan Grain Delivery Points



Friction factors are key inputs to the gravity model and are measures of the attractiveness between origins and destinations. Friction factors are inversely proportional to impedances (transport distance); as the distance to transport grain from an origin to a destination increases, the attractiveness of delivering grain from that origin to that destination decreases, along with the friction factor. The volume of grain estimated to move between an origin-destination pair depends on the size of the friction factor; the higher the friction factor, the more grain moves from a 1984/85 delivery point to a 2003/04 delivery point. Friction factors are estimated using the impedance (transport distance) between origin-destination pairs and an impedance function.

Impedance functions relate the impedance, or transport distance, to the attractiveness, or friction factor, between origins and destinations. Exponential, inverse power and gamma functions can be used as impedance functions in the gravity model. The FHWA *Quick Response Freight Manual* recommends an exponential function as the impedance function to determine friction factors for the gravity model as it has been used previously in studies to forecast freight movements²¹ and was therefore used in this study. Using the exponential impedance function and the estimated transport distances, friction factors were determined for transporting grain between each origin 1984/85 grain delivery point and destination 2003/04 grain delivery point.

The friction factors based on transport distance and the grain haul production and attraction information developed during the grain haul generation component were input to the gravity model in TransCAD. The gravity model yields estimates of the grain haul flow between all origins and destinations. The results are stored in an origin-destination matrix that lists the volume of grain moving between each 1984/85 grain delivery point and 2003/04 grain delivery point. The model allows grain originating in one 1984/85 grain delivery point to be delivered to more than one 2003/04 grain delivery point. Manual checking and calibration of the origin-destination results was conducted to ensure realistic results.

8.4 Grain Haul Assignment

Grain haul assignment is the final step in the grain haul forecasting model. Grain haul volumes on individual road links are estimated by assigning grain haul to the road network based on the origin-destination information developed in the grain haul distribution component. The assignment process determines the travel routes between origins and destinations, and hence the estimated grain haul volume on individual road links.

²¹ U.S. Department of Transportation, *Quick Response Freight Manual*. Washington, D.C., 1996.

8.4.1 Unrestricted Scenario

Geographic files containing the Saskatchewan provincial road network and the major municipal roads were obtained from SHT. The geographic files were combined to form a single continuous road network that contains over 24,500 kilometres of provincial roads and approximately 55,700 kilometres of major municipal roads²². All Saskatchewan roads, both provincial and municipal, are categorized into the following seven classes based on the function of each road in terms of social, economic, and connectivity considerations.²³

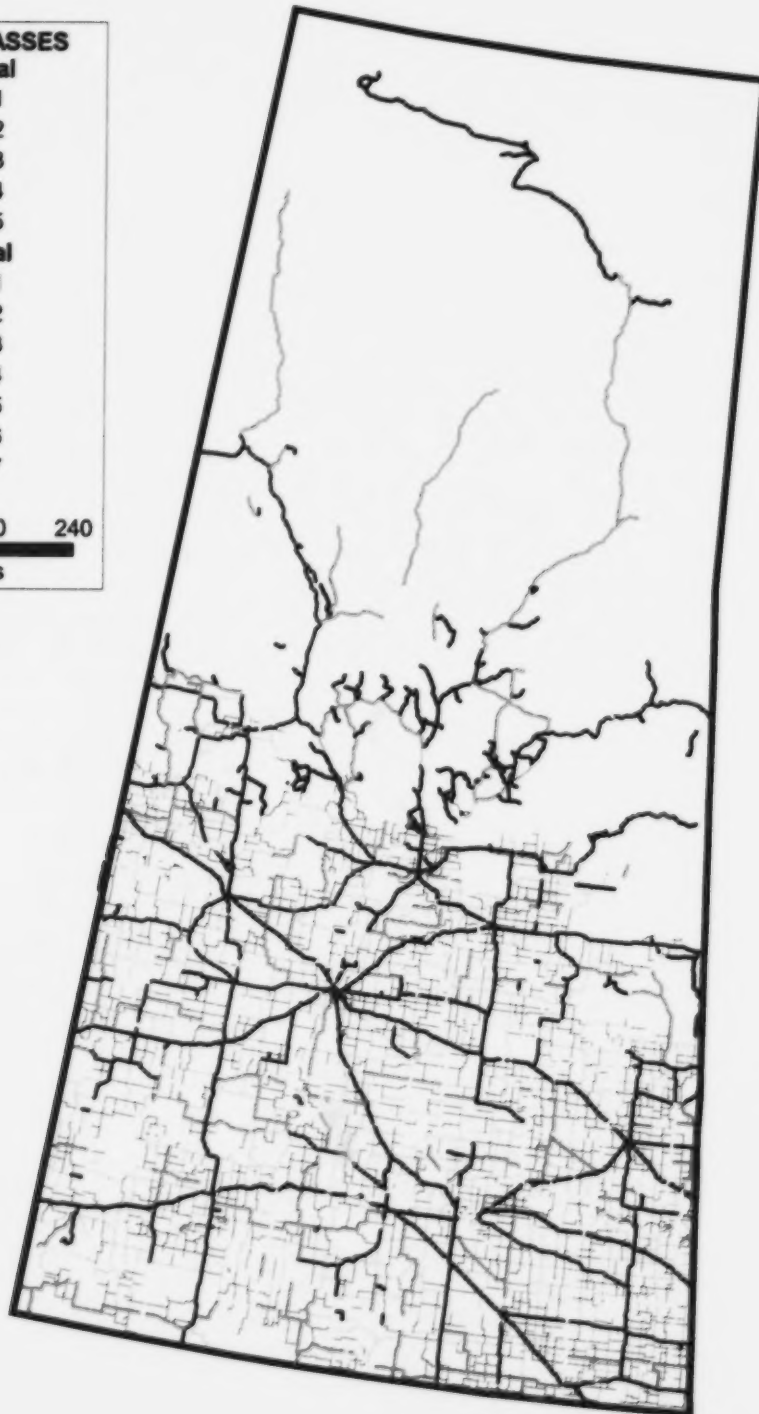
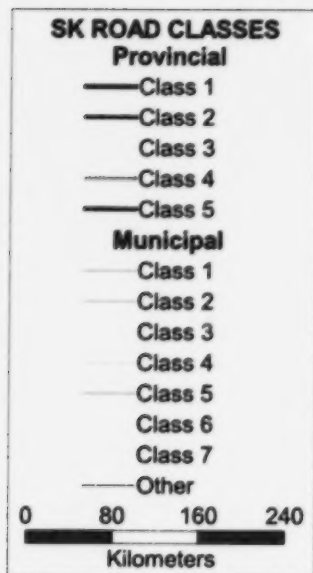
- **Class 1** roads serve as major inter-provincial and international travel routes as well as connecting centres with 3,000 or greater population (three percent of the total road system).
- **Class 2** roads serve communities with 1,000 or greater population and link hospitals to regional or base hospitals (two percent of the total road system).
- **Class 3** roads serve communities of 500 or greater population and link special care homes or health centres to hospitals (three percent of the total road system).
- **Class 4** roads serve as primary inter-municipal links and provide access to communities of greater than 100 population and large industrial sites (10 percent of the total road system).
- **Class 5** roads serve as secondary inter-municipal links and provide access to communities with less than 100 population and medium industrial sites (11 percent of the total road system).
- **Class 6** roads serve individual residences, school bus routes and small industrial sites (34 percent of the total road system).
- **Class 7** roads provide access to the land (37 percent of the total road system).

The Saskatchewan road network used for the grain haul assignment model is illustrated in Exhibit 8.2.

²² The road network used for the modeling, supplied by SDT, includes approximately 3,900 km of Class 1 roads; 5,100 km of Class 2 roads; 6,000 km of Class 3 roads; 19,800 km of Class 4 roads; 21,700 km of Class 5 roads; 22,600 km of Class 6 roads and 1,200 km of Class 7 roads. Incremental grain haul would occur mainly on Class 2 to 5 municipal roadways and provincial highways. Urban municipal links were not originally included but added where necessary for system connectivity for modeling purposes.

²³ Saskatchewan Association of Rural Municipalities, Saskatchewan Urban Municipalities Association, Saskatchewan Highways and Transportation, and Saskatchewan Municipal Affairs Culture and Housing, *Rural Road Classification Report*. December 1999.

Exhibit 8.2: Saskatchewan Road Network



The assignment of grain haul to the road network is based on the cost of travel. The cost of travel can be a function of a number of variables, including transport time, capacity, and distance. For this project, the cost of travel is based on transport distance. However, there are additional differences between road links besides transport distance that can make one route more attractive than another. If a road link is more attractive than a second road link, travel is more likely to take place on the first link. Link travel costs must be adjusted to account for different road characteristics through the use of link adjustment factors.

Link adjustment factors are estimated based on the available road characteristics that impact the selection of a travel route and were determined for each individual link in the Saskatchewan road network. The link adjustments used in the grain haul assignment model are summarized in Exhibit 8.3 and described below.²⁴

Exhibit 8.3: Link Transport Distance (Travel Cost) Adjustments

Road Characteristic	Rating	Distance Adjustment
Divided versus Undivided	Divided	--
	Undivided	+ 10 %
Surface Type	Paved	--
	Unpaved	+ 15 %
Weight Class	Primary	--
	Secondary	+ 25 %
	Restricted	+500%

- **Divided versus Undivided:** Divided roadways are higher class facilities with additional lanes and are more desirable and attractive than undivided roadways. Link travel distance was increased by 10 percent for all undivided roadways²⁵. All links with no divided/undivided information available were assumed to be undivided.

²⁴ ND LEA Engineers and Planners, *Transportation Planning Model for the Grain Transportation System in Manitoba*. Prepared for Manitoba Transportation & Government Services, August 2002.

²⁵ Divided highways are more attractive than non-divided highways as they are safer and lessen the driving task, especially in overtaking manoeuvres. Due to the limited amount of divided highways in the overall network, this factor does not have a significant effect on overall traffic assignments.

- **Paved versus Unpaved:** Paved roadways provide a smooth riding surface and are more desirable and attractive than unpaved roadways²⁶. Link travel distance was increased by 15 percent for all gravel roadways. All links with no surface type information were assumed to be unpaved.
- **Weight Restrictions:** Roadways are classified by the maximum number of truck loadings that can be accommodated on a year-round basis (some roadways have seasonal loading restrictions). Weight classes in Saskatchewan are defined as follows:²⁷
 - **Primary** roadways allow the highest weight loadings and permit vehicles with a maximum gross vehicle weight of 62.5 tonnes for 8-axle B-trains.
 - **Secondary/Municipal** roadways allow medium weight loadings and permit vehicles with a maximum gross vehicle weight up to approximately 55 tonnes for 8-axle B-trains.
 - **Weight Restricted** roadways only allow trucks to operate with a permit. In most cases, an alternate, parallel route has been set up in partnership with the rural municipalities to accommodate truck traffic.

Primary roadways are considered most attractive as they allow the largest and heaviest vehicles. Link travel distance was increased by 25 percent for all Secondary and Municipal roadways²⁸. Link travel distance was increased by 500 percent for all Weight Restricted roadways, effectively negating these routes for grain haul. All provincial links with no weight information were assumed to be Secondary roads.

The link adjustments are applied to actual travel distances using a link impedance function to estimate the adjusted travel distance for each road link. The link impedance function is as follows:

$$L_j = l_j * r_j$$

where L_j = adjusted length of link j in kilometres

l_j = actual length of link j in kilometres

r_j = travel distance adjustment factor on link j

²⁶ Paved roads reduce truck operating costs by approximately 10% - 15% compared to unpaved roads. Refer to Transport Canada report Operating Costs of Trucks in Canada, the higher factor was chosen as the paved roads are also more attractive to drive on from a ride comfort point of view.

²⁷ DS-Lea Consultants Ltd. in Association with the Battelle - UMTIG Prairie Freight Studies Alliance, *Prairie Provinces Transportation System Study*. Prepared for Transport Canada, December 1998.

²⁸ Primary weights increase truck productivity by approximately 25% compared to secondary weights.

The total adjustment factor for each link, r_j , is a mathematical product of all adjustments. For example, consider an undivided gravel road with a Secondary weight restriction. The adjustment factor for this particular link is estimated as:

$$r = r_{\text{divided/undivided}} \times r_{\text{paved/unpaved}} \times r_{\text{weight restriction}}$$

$$r = 1.10 \times 1.15 \times 1.25 = 1.58125$$

Once the adjusted lengths were determined for each road link, the Origin-Destination Matrix was used to distribute grain to the road network using the All-or-Nothing assignment process in TransCAD. The All-or-Nothing assignment process distributes grain based on the least cost route. All grain moving from a 1984/85 grain delivery point to a 2003/04 grain delivery point travels via the same route. The All-or-Nothing assignment process does not consider the capacity of road links or the effects of congestion during the assignment process²⁹, however; link capacities and road congestion are not considered to be problems for grain haul movements on most Saskatchewan roads. Almost all regional freight assignments are based on the All or Nothing assignment methodology.³⁰ The resultant assignment of incremental grain haul tonnages on the Saskatchewan road network is illustrated in Exhibits 8.4A to 8.4D.

SHT is currently developing a model to predict farm gate to delivery point grain movements in Saskatchewan. The Saskatchewan Grain Flow Model v2004 estimated 810 million tonne-kilometres of 2003/04 grain haul based on a total delivered tonnage of 14.7 million tonnes. Assuming approximately 190 million tonne-kilometres of grain haul in 1984/85, the incremental grain haul is estimated at 620 million tonne-kilometres.

The grain haul assignment model developed for this study estimated 620 million tonne-kilometres of incremental grain haul based on a total tonnage of 14.1 million tonnes of grain. Increasing the total tonnage from 14.1 million tonnes to 14.7 million tonnes results in an estimated incremental grain haul of approximately 646 million tonne-kilometres, which is less than a five percent difference from the SHT estimate.

²⁹ Black, William R., *Commodity Flow Modeling*. Indiana University, Transportation Research Circular, Irvine, California, 1999.

³⁰ Huang, Wen-Jing, *Development of Statewide Truck Travel Demand Models Using Multiple Data Sources*. University of Wisconsin-Madison, 1998.

Exhibit 8.4A: Incremental Grain Haul Assignment for the Unrestricted Road Scenario (Northeast Saskatchewan)

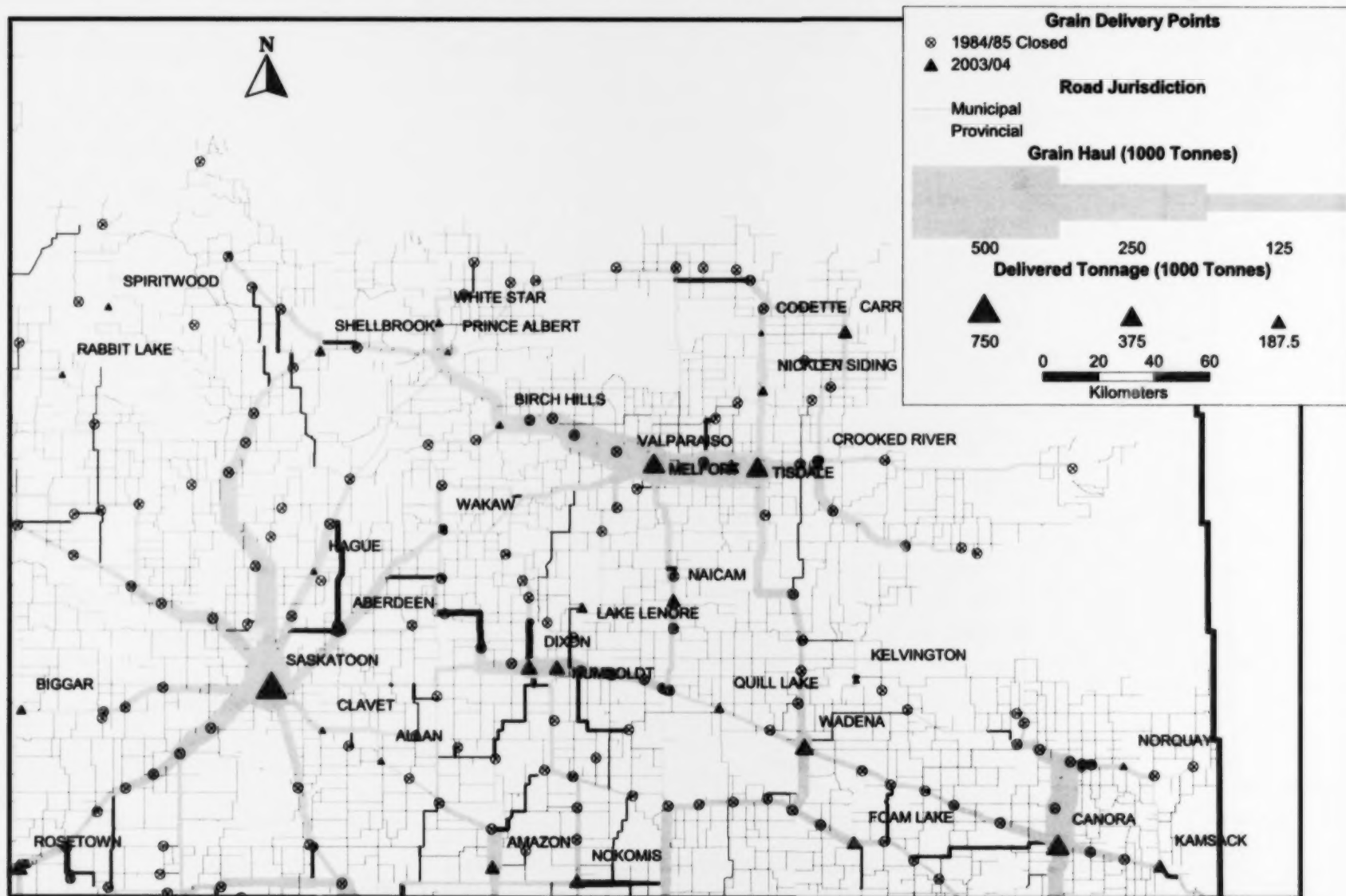


Exhibit 8.4B: Incremental Grain Haul Assignment for the Unrestricted Road Scenario (Southeast Saskatchewan)

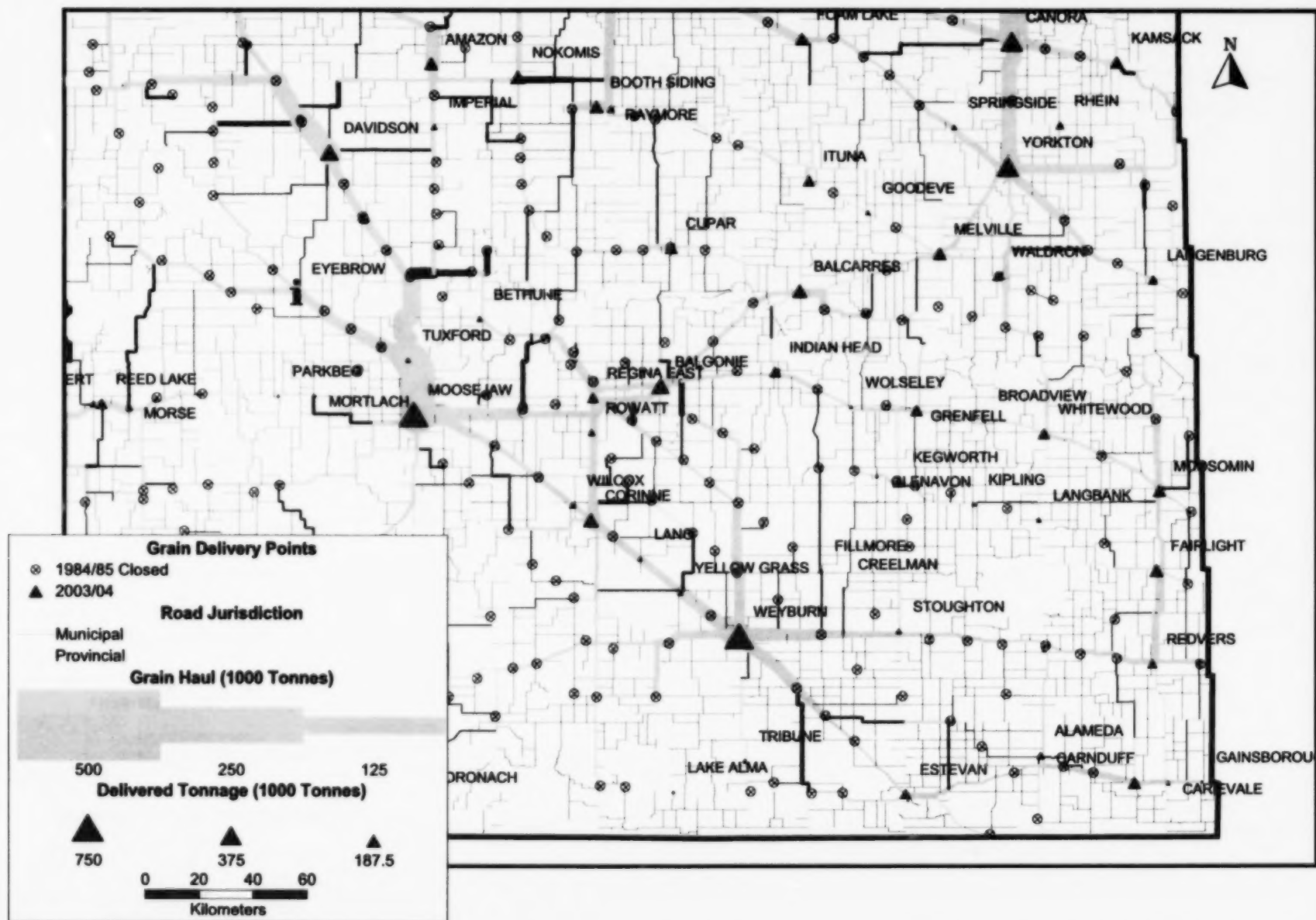


Exhibit 8.4C: Incremental Grain Haul Assignment for the Unrestricted Road Scenario (Southwest Saskatchewan)

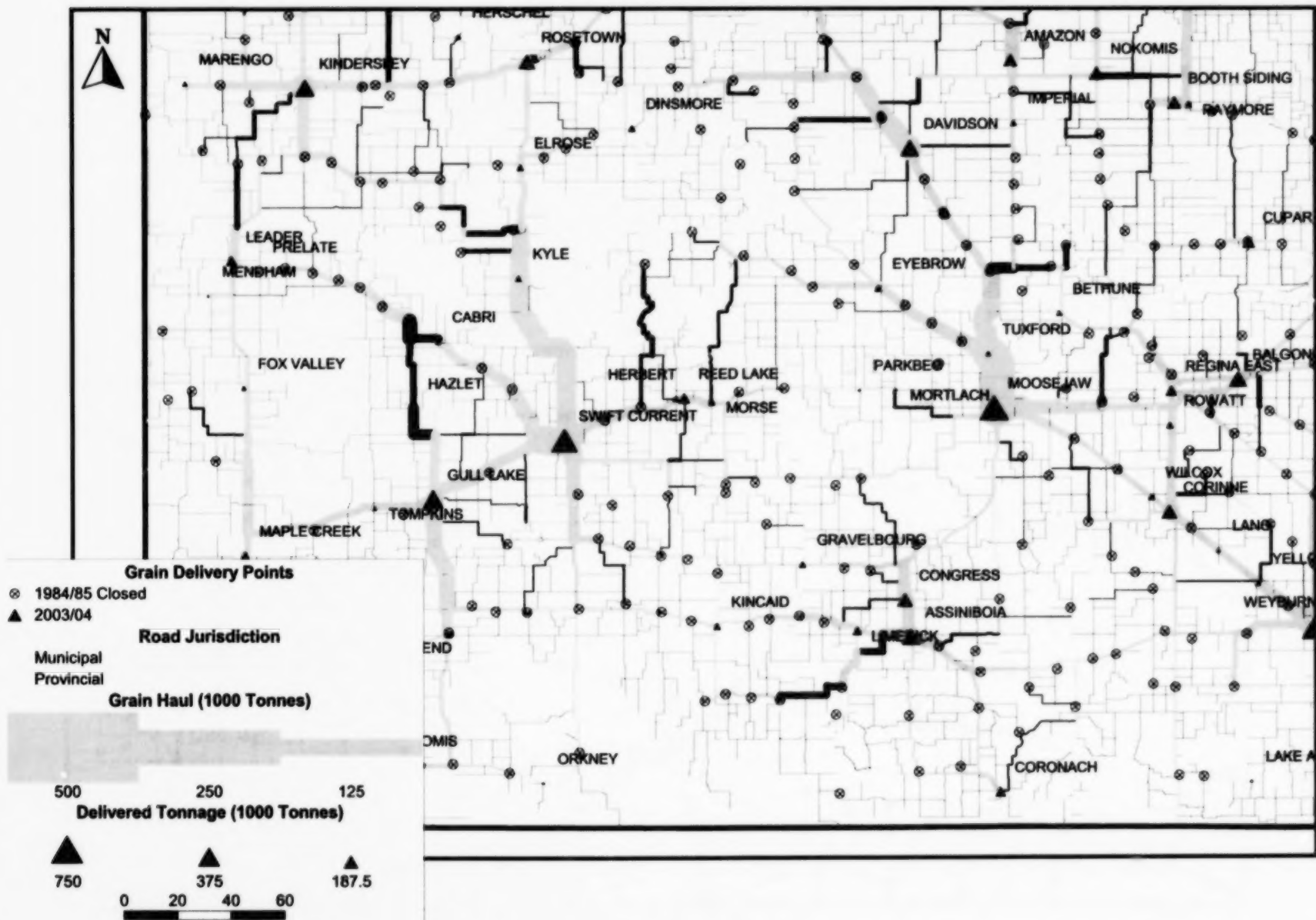
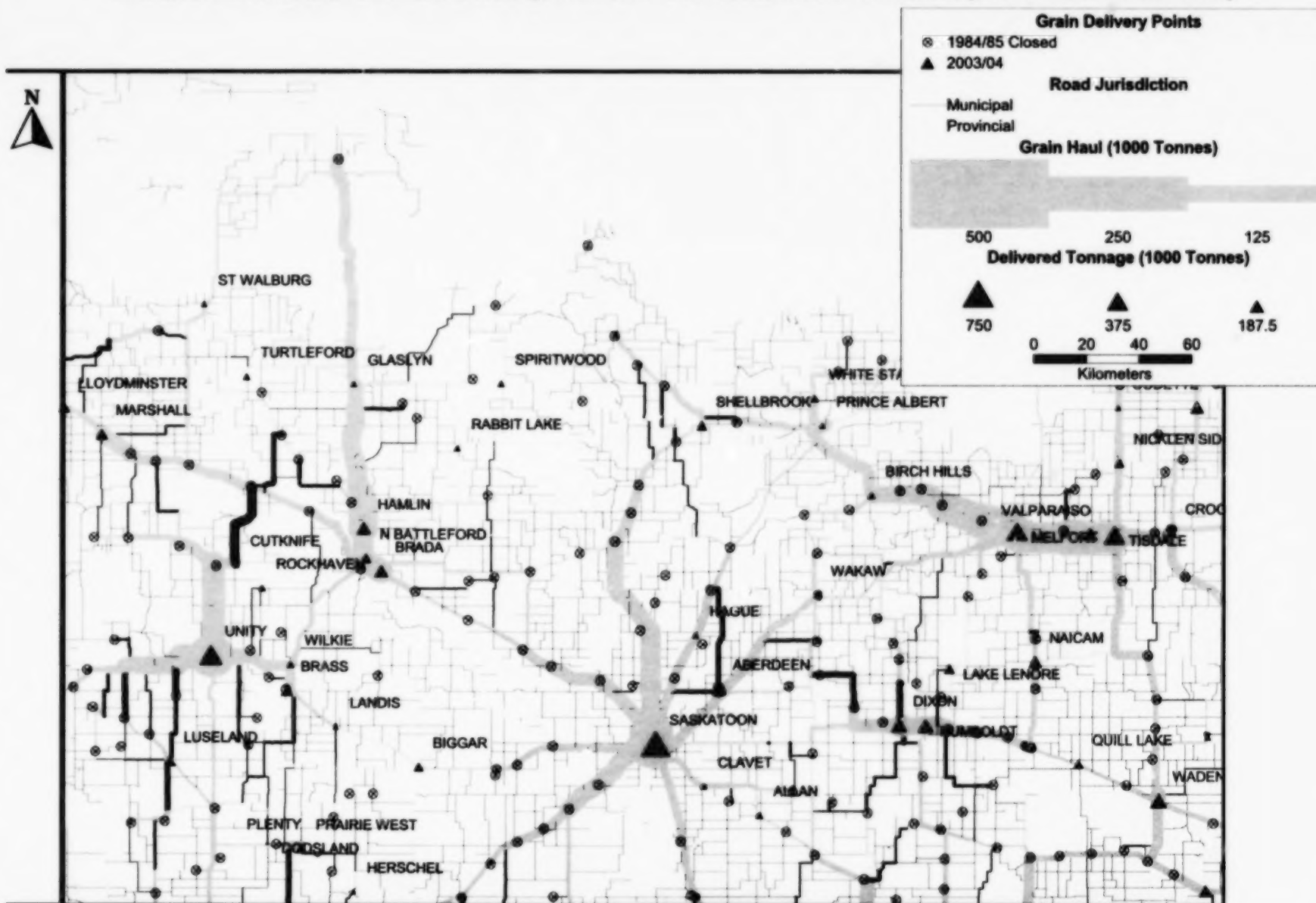


Exhibit 8.4D: Incremental Grain Haul Assignment for the Unrestricted Road Scenario (Northwest Saskatchewan)



8.4.2 Grain Corridor Scenario

A recent study examined the existing grain haul system and recommended a province-wide strategic grain haul network for Saskatchewan's municipal roads.³¹ The Saskatchewan Grain Corridor system is a road network made up of provincial and municipal roads that encourages grain travel by specific routings. The recommended Grain Corridor system is illustrated in Exhibit 8.5.

A second traffic assignment was conducted where grain haul was encouraged to use roadways designated as part of the Saskatchewan Grain Corridor system.

For the purposes of this traffic assignment, all roads that were not designated as part of the Grain Corridor system were assigned an additional travel length adjustment factor, thereby penalizing roads that are not part of the Grain Corridor network and making them less attractive for grain haul. An adjustment factor of 200 percent ($r = 2.00$) was used. This factor makes the non-Grain Corridor system roads less attractive, but is not large enough to result in unrealistic travel patterns (i.e., vehicles travelling large distances out of their way to access a Grain Corridor roadway). The resultant assignment of incremental grain haul tonnages for the Saskatchewan Grain Corridor scenario is illustrated in Exhibit 8.6A to 8.6D.

Note: As the report was nearing completion the consultant was asked to analyze a third grain traffic scenario. This scenario assumes that all municipal roads that are designated as part of the Grain Corridor system allow primary weight loadings.

To complete this analysis, the weight adjustment factor of 25 percent associated with secondary weight loadings was removed from the municipal grain corridor roadways and new adjusted lengths were determined for each road link in the network. All other assumptions were assumed to be the same as those used in the Grain Corridor scenario. Once the adjusted lengths were determined for each road link, the Origin-Destination Matrix was used to distribute grain to the road network using the All-or-Nothing assignment process in TransCAD.

The traffic assignment maps for this scenario are shown in Appendix 3.

Exhibit 8.5: Saskatchewan Grain Corridor System

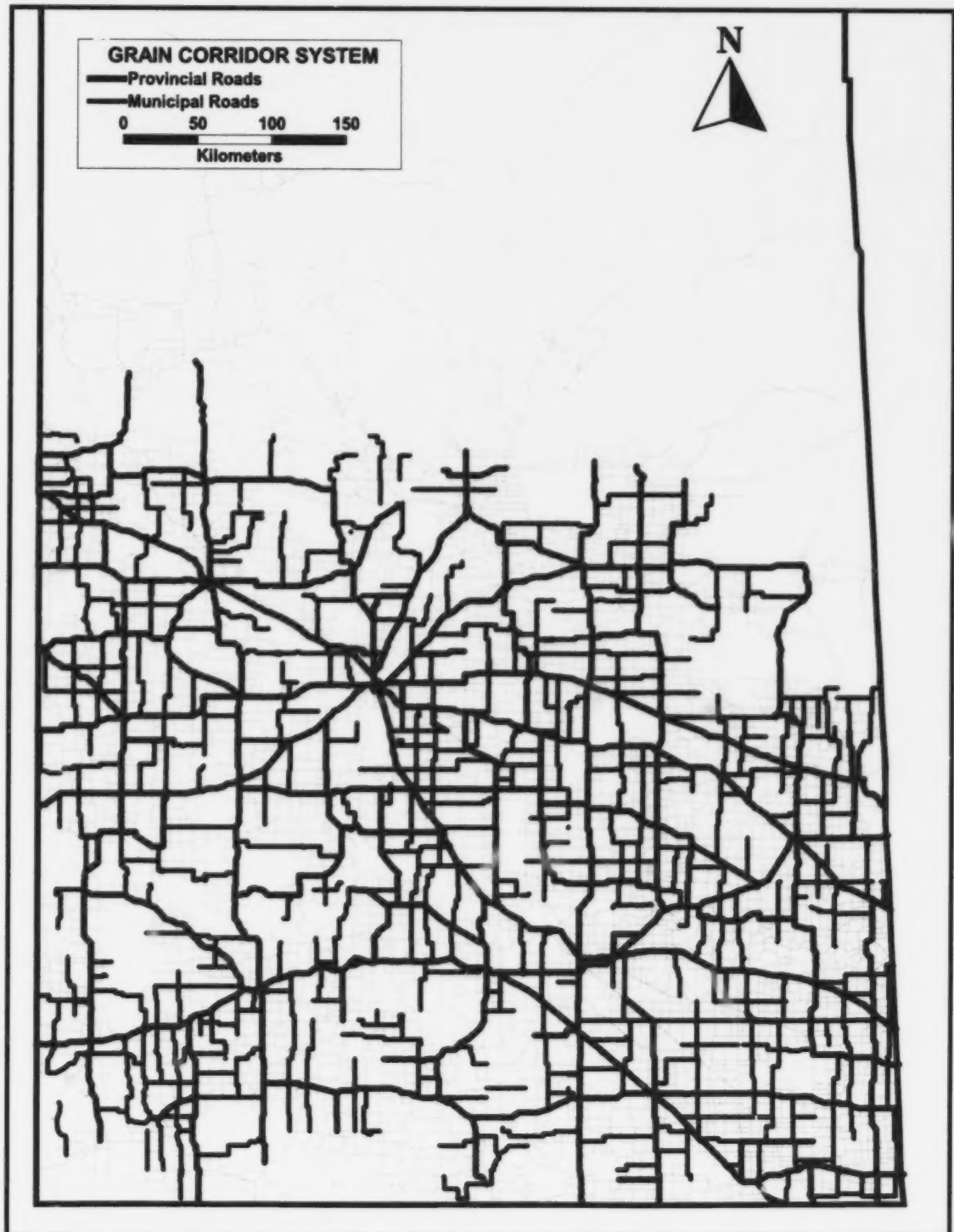


Exhibit 8.6A: Incremental Grain Haul Assignment for the Grain Corridor Scenario (Northeast Saskatchewan)

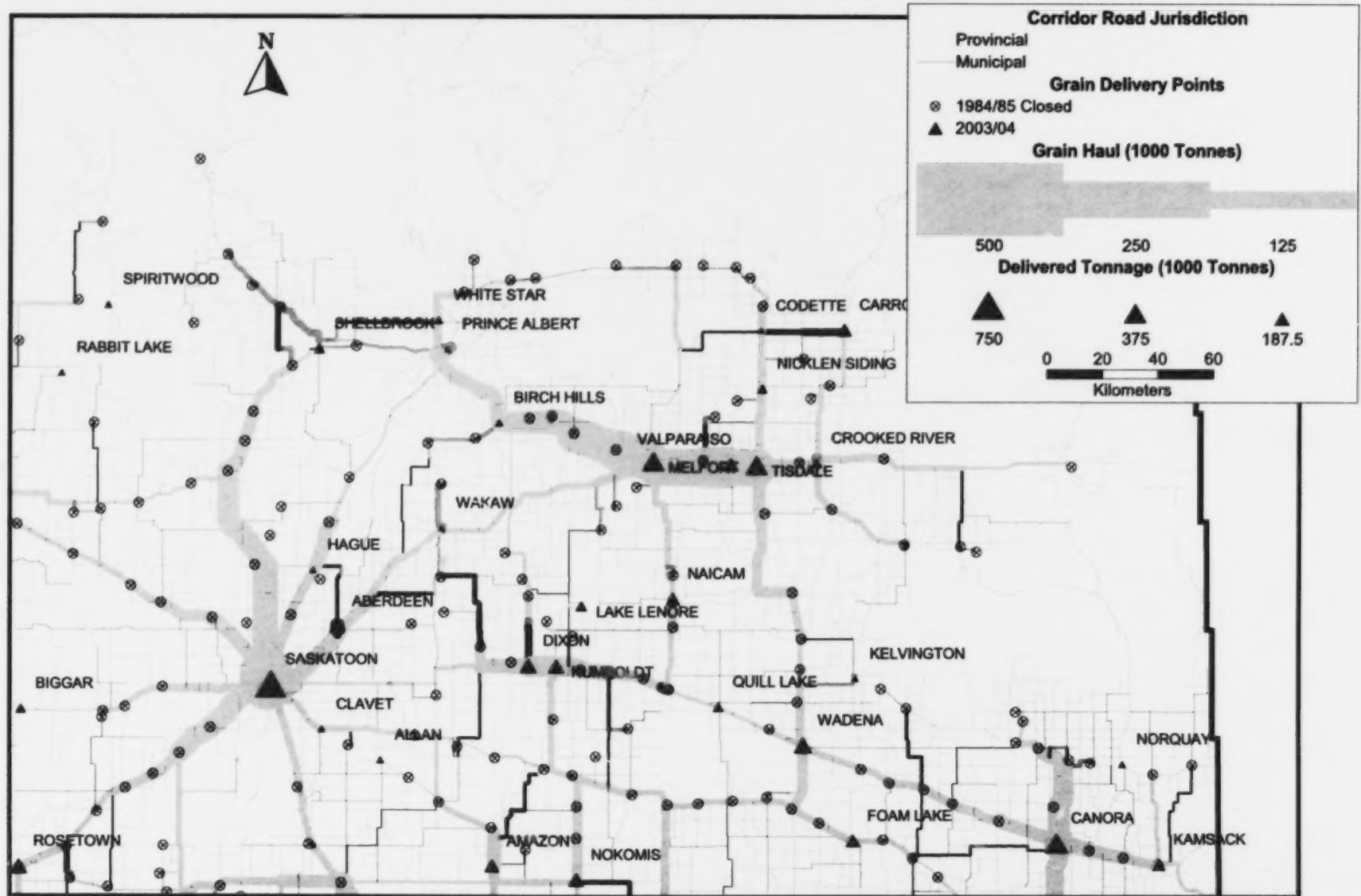


Exhibit 8.6B: Incremental Grain Haul Assignment for the Grain Corridor Scenario (Southeast Saskatchewan)

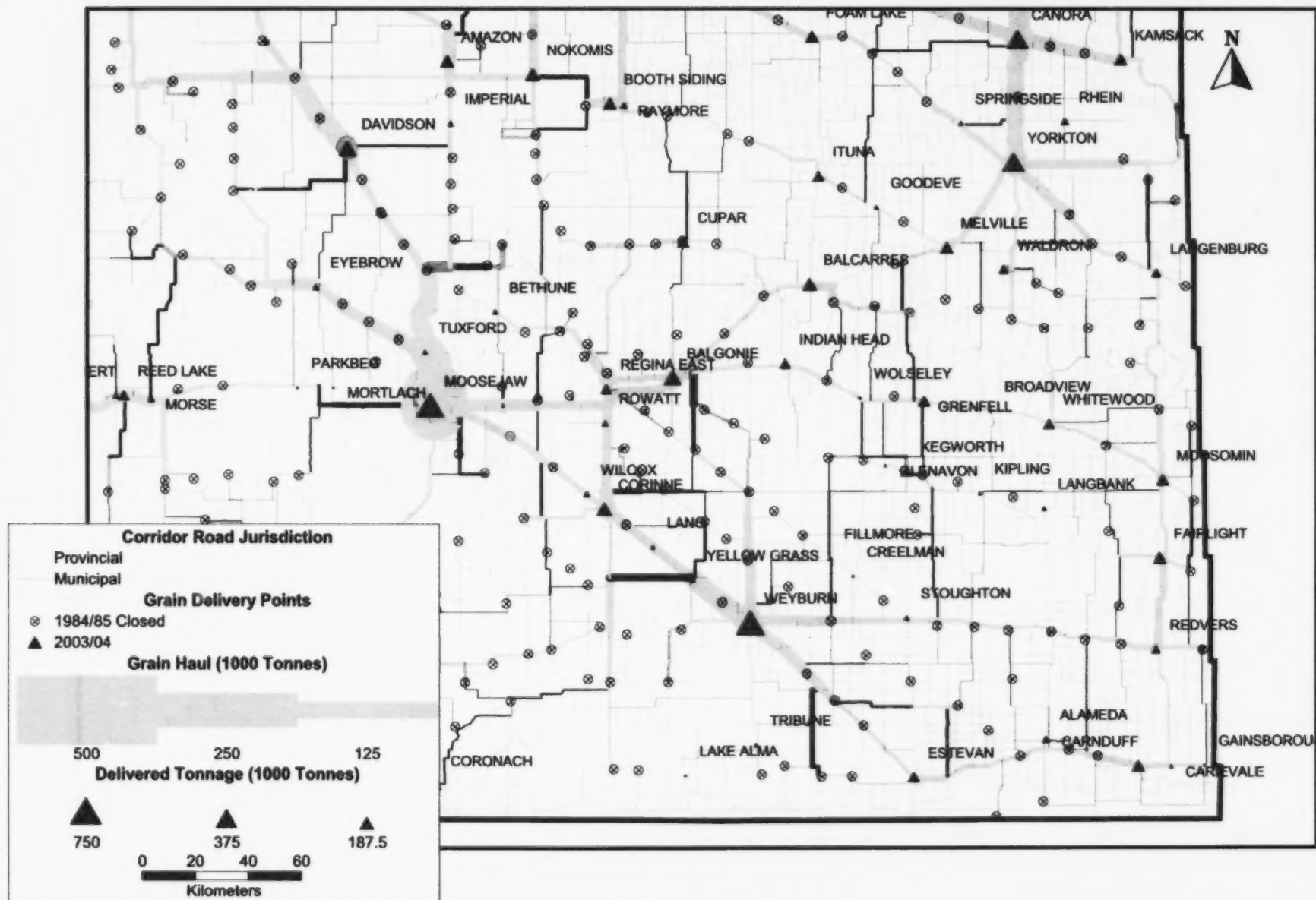


Exhibit 8.6C: Incremental Grain Haul Assignment for the Grain Corridor Scenario (Southwest Saskatchewan)

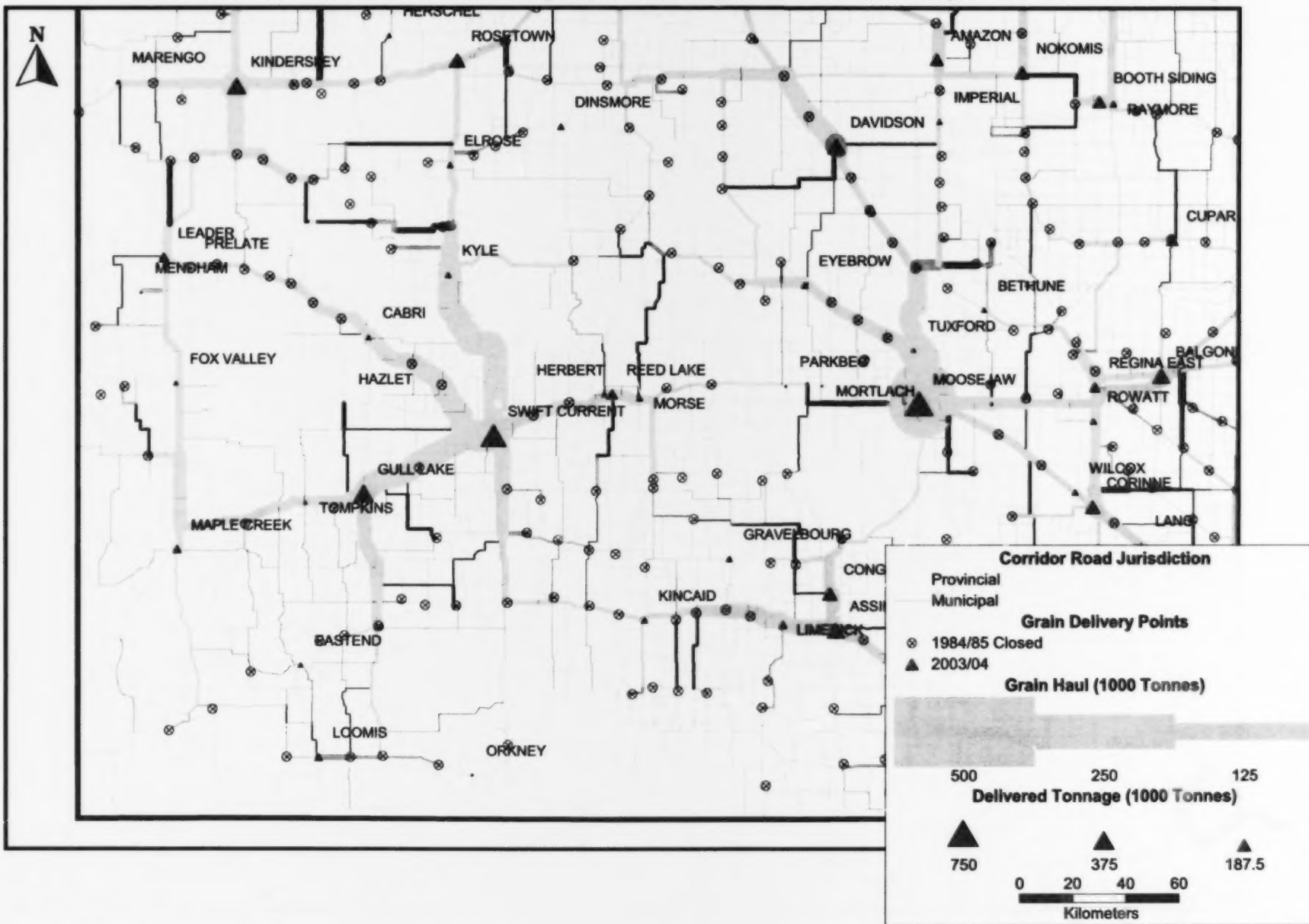
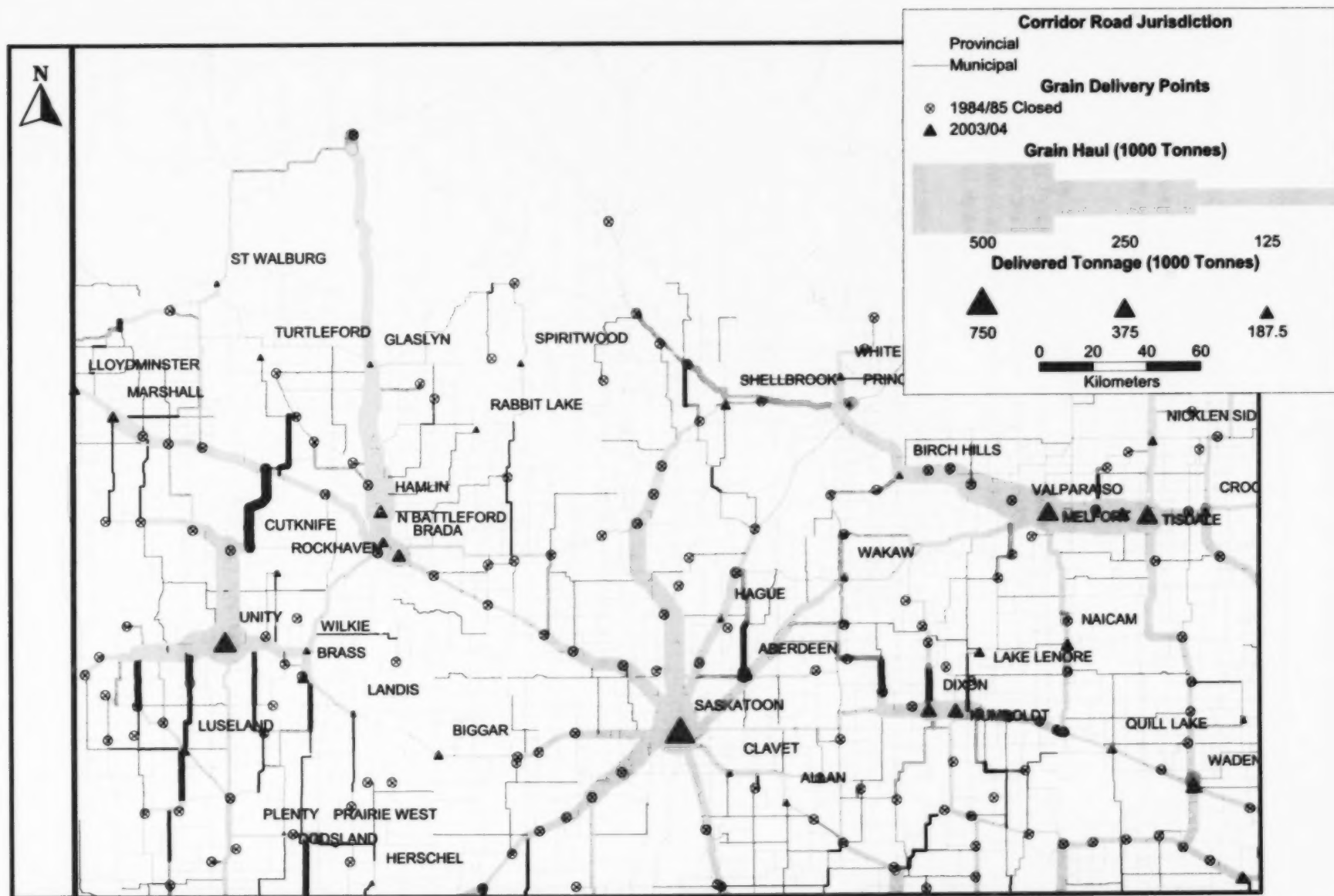


Exhibit 8.6D: Incremental Grain Haul Assignment for the Grain Corridor Scenario (Northwest Saskatchewan)



9.0 ROAD IMPACT COSTING METHODOLOGY

To estimate the road impact costs of the additional grain truck haul, costs per tonne-kilometre are developed for each road surface type using life cycle costing procedures.

The unit rates are based on cost information provided in the Department's standard drawing Typical Rural Highway Cross-Sections provided in Appendix 1. All costs are reported in 2004 dollars. The study considers the impact of grain haul on traffic related variable costs including surfacing, surface preservation and maintenance, and resurfacing costs.

The cost of upgrading non-sustainable TMS roads was also included. It is assumed that grain haul does not affect basic road component costs such as right-of-way, ditching and grading. The analysis was done for the thinnest and thickest pavement structures given in the standard as well as for one of average or mid-depth.

The provincial RM road database was obtained and sorted to determine the RMs that had TMS, paved and gravel roads. Six RMs were contacted to determine if they could provide maintenance cost information; however, none of these RMs kept segregated costs. The maintenance costs they keep make no distinction between surface types or blading, mowing, snow removal, etc.

The database was also reviewed for roads where the Department obtains agreements with RMs to have truck traffic diverted from TMS roads to adjacent gravel roads. However, the information was not usable because it includes all costs such as snow removal, mowing, etc. Some specific data was obtained from the RM of Corman Park; however, it cannot be considered representative since Corman Park is in the immediate vicinity of Saskatoon. It was concluded that the Department's own unit rates for traffic related surface maintenance costs were the best available and representative of a desirable level of service to be maintained for RM maintenance as well. Without specific cost analysis which is beyond the scope of this study, there was no information available to pro-rate these for RM considerations.

9.1 Structural and Granular Pavement Roads

9.1.1 Average Annual Surfacing Costs

Life-cycle cash flows were calculated for the surfacing of asphalt concrete and granular pavement highways. Using the per kilometre rates provided for the standard designs in Appendix 1, life-cycle cash flows were calculated over a 40-

year period³². This period was considered appropriate to cover the full life of a pavement before total reconstruction. The maintenance cost stream for asphalt concrete highways is based on that used in the SaskBEN model³³, with costs updated to 2004 dollars and applied to a two-lane road. The standard uses a design life of 15 to 20 years for AC pavements before resurfacing; 15 years was used in this study. The analysis for granular pavements used the designated life of 15 years before resurfacing.

It is assumed that, system-wide, the age distribution of the individual road sections is evenly spread over the life-cycle. The average annual cost per kilometer of road in the system is therefore equal to the total life-cycle cost of one road divided by the life years. Appendix 2 shows the detailed calculation. Exhibit 9.1 below summarizes the results based on the range of pavement thickness given in the standard. The structural depth required for a specific road depends on the traffic level (predicted Equivalent Single Axle Loads or ESALs) and the local subgrade CBR³⁴. It is expected that this range covers all conditions encountered within the province.

Exhibit 9.1: Average Annual Pavement Costs (2004 Dollars / 2-lane km)

Pavement Type	Pavement Strength (Depth)		
	Average	Low (Thin)	High (Thick)
Asphalt Concrete	\$16,684	\$15,830	\$17,537
Granular	\$11,541	\$9,834	\$13,249

9.1.2 ESAL Calculations

Equivalent Single Axle Load (ESAL) is the standard method for examining the impact of truck traffic on structural pavements. The formula provided in the Department's Surfacing Design Manual was used to calculate Equivalent Single Axle Loadings (ESALs). The formula relates the weight on any given axle or axle group to a standard axle loaded at 80 kN as follows:

$$\text{ESAL} = (\text{Load of Axle or Axle Group}/\text{AF})^{3.84}$$

where AF is an adjustment factor dependent on the axle or axle group loading and configuration. The detailed calculation of ESALs is given in Appendix 2 and summarized below.

³² The costs shown in the Department's standard drawing Typical Rural Highway Cross-Sections provided in Appendix 1 use a 40-year life cycle.

³³ The SaskBEN model is an adaptation for Saskatchewan application of MicroBENCOST, a computer model for benefit/cost analysis of transportation systems.

³⁴ California Bearing Ratio (CBR) is a measure of the soil strength used in the design of road pavements. It is based on a plate test of ground deflection under a standard load.

For grain trucks, ESALs were calculated for all grain truck types reported in the grain audit and are given in Exhibit 9.2. The calculation assumes that all grain trucks travel loaded in the direction toward the grain terminals. This would then be considered the critical lane for design since all other trucks are evenly split by direction and empty grain truck ESALs were therefore not considered. The number of ESALs per tonne of grain was calculated by weighting the ESAL for the individual truck configuration with the distribution of truck types measured in the survey. This information is subsequently used to calculate the cost impact of transporting one tonne of grain one kilometre. This is in turn multiplied by the number of tonne-kilometres of incremental haul to determine the cost impact of the incremental haul on structural pavements.

Exhibit 9.2: ESALs for Grain Trucks

ESALs for Grain Trucks (From Grain Haul Audit)						
Configuration	GVW	Payload	ESALs	Distribution	ESAL/ Tonne	Incremental ESALs
2-Axle Straight	15,260	7,224	5.25	20.06 %	0.73	0.15
3-Axle Straight	24,964	13,128	7.31	12.00 %	0.56	0.07
5-Axle Semi	34,731	17,537	3.85	26.84 %	0.22	0.06
6-Axle Semi	43,630	25,893	5.05	14.88 %	0.19	0.03
7-Axle A-Train	50,179	30,264	5.50	4.29 %	0.18	0.01
8-Axle B-Train	58,782	38,182	6.51	21.94 %	0.17	0.04
ESALs / Tonne Grain						0.35

Pavement design ESALs were derived from the Paving Manual design chart for CBR = 5. The design ESALs equivalent to each of the high, low and medium strength pavements depths given in the standard cross sections were interpolated from the design curves.

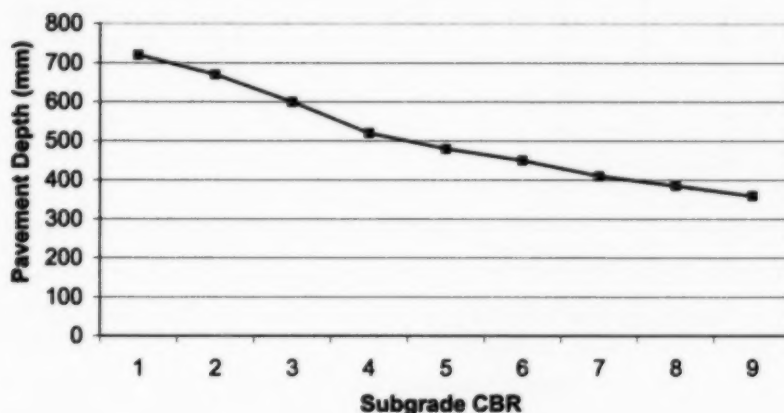
9.2 Cost Calculation for Haul on Paved Highways

To establish the cost of haul for all trucks on structural pavements, typical costs per ESAL km were established for the high, low and mid-range of the design structures given in the Department's Typical Rural Highway Cross Sections, using the average annual life-cycle costs previously calculated. Haul cost per ESAL km multiplied by ESALs per tonne of grain then yielded the cost per tonne km for grain haul.

Knowledge of the local subgrade CBR is essential to determine the structural depth of pavement required at any traffic level. Consultation with an experienced Saskatchewan highway pavement design engineer established that a CBR of 5 is fairly representative of average Saskatchewan soil bearing capacity. To illustrate the sensitivity of the results to this estimate, Exhibit 9.3 shows the decrease of

total pavement depth (or the equivalent granular depth) with increase in the subgrade CBR. The relationship is approximately linear with greater sensitivity at CBR below 5. Pavement costs could be expected to vary approximately in direct proportion to pavement depth.

Exhibit 9.3: Sensitivity of Pavement Depth to CBR

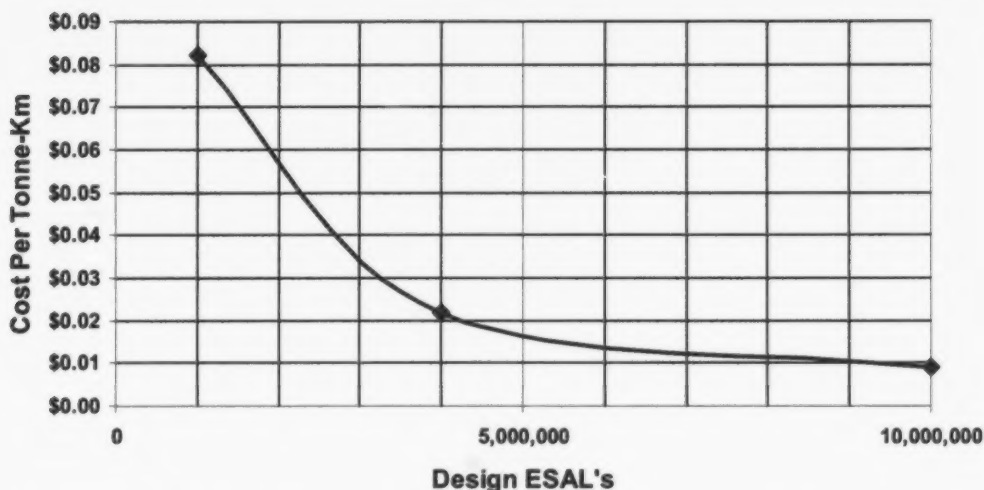


The cost of grain haul per tonne-km was calculated in the following steps:

- The annual cost of pavement per ESAL-km is equal to the annual life-cycle costs from Exhibit 9.1 divided by the design ESAL.
- The cost of grain haul per tonne-km is then ESALs/tonne of grain multiplied by the cost per ESAL-km.

The results of the calculation of AC pavements are plotted in Exhibit 9.4. The methodology charges the full cost of the surface structure and summer surface maintenance of the road to trucks only. As can be seen from the plot, the cost rises quite sharply at ESAL levels below 5,000,000. This reflects the fact that below that as the ESAL design level decreases, it becomes less realistic to charge all costs to trucking only and some basic facility costs must be assigned to all other traffic.

Exhibit 9.4: Structural AC Pavements Cost per Tonne-Km vs Design ESAL's



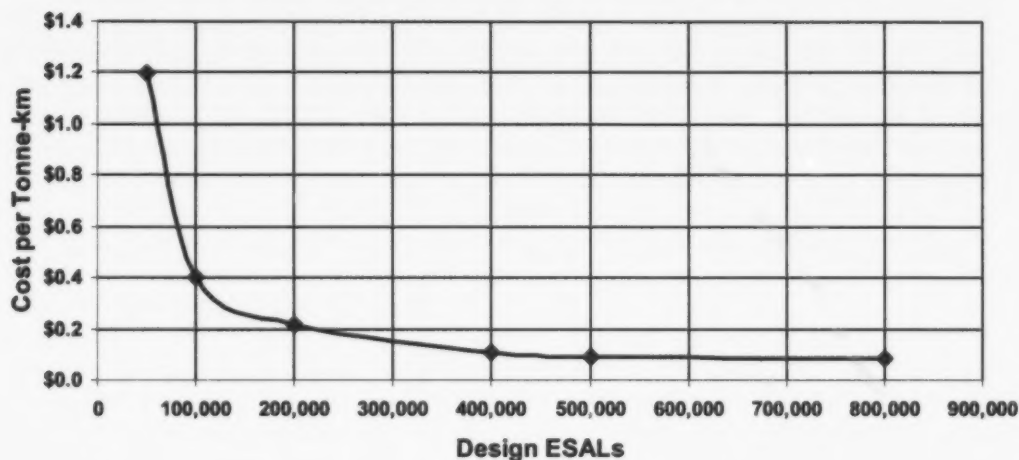
The detailed calculation of grain-haul costs for AC and granular pavements is given in Appendix 2.

The grain haul cost calculation for AC pavement uses \$0.0091 for 10M design ESALs and above, straight line interpolation between \$0.0091 at 10M and \$0.0216 at 4M ESALs, and between \$0.0216 at 4M and \$0.0821 at 1M ESALs, and then constant at \$0.0821 below 1M ESALs. The cost of lower volume roads is more sensitive to traffic levels. However, very few of the sections below 1M ESALs are AC surfaced. As a result, these sections account for only 6% of incremental grain traffic on AC surfaced roads. This means that use of a rate higher than \$0.0821 for these sections would have little impact on overall costs.

Since traffic volumes on municipal roads are at the low end of the scale, a rate of \$0.0821 per tonne-km was used for RM asphalt concrete surfaced roads. There are, in fact, very few of these surface types on RM roads.

The results of the calculation of granular pavements are plotted in Exhibit 9.5. For granular pavements, the cost rises quite sharply for ESAL levels below 200,000, however, there are few sections below that level.

The cost calculation for granular pavements was done using a minimum rate of \$0.0859 at or above 800,000 ESALs and linear interpolation from \$0.0859 at 800,000 ESALs to \$0.1094 at 400,000 ESALs, and linear interpolation from \$0.1094 at 400,000 ESALs to \$0.2126 at 200,000 ESALs and then constant at \$0.2126 below 200,000 ESALs.

Exhibit 9.5: Granular Pavement Cost per Tonne-Km vs Design ESALs

9.3 TMS and Gravel Surfaced Roads

9.3.1 Average Annual Surfacing Costs

Average annual life-cycle costs of TMS and gravel-surfaced roads were calculated using the same life-cycle procedures as used for pavements, but using a surface life of 20 years which reflects the time between major resurfacings for these road surface types. The annual maintenance costs given with the typical standard were taken as constant throughout the life of the surface. The cost range for TMS covers low, average and high maintenance conditions. As provided in the typical standard, only one average condition is considered for gravel-surface roads. The annual life-cycle TMS and gravel surfacing costs per two-lane kilometer of road are given in Exhibit 9.6.

**Exhibit 9.6: Average Annual TMS and Gravel Surfacing Costs
2004\$ / 2-lane km**

Surface Type	Cost Range		
	Average	Low	High
TMS	\$6,591	\$5,909	\$7,273
Gravel	\$2,313	\$2,313	\$2,313

9.3.2 Weighted Number of Axles

There is no mechanism for load transfer between groups of axles for a road surface with no underlying pavement structure. The calculation of ESALs is therefore not valid for this type of road. In this analysis, axles on thin surfaces are considered to act independently, with the damage or wear imparted to the surface being in direct proportion to the weight on each axle. In fact, the impact is not likely linear relative to weight on each axle, but it was considered as such for lack of any known modification factor. It is expected that any error inherent in this assumption will mainly cancel out when considering the relative impact of one group of trucks (grain-haul) compared to another (all highway trucks). A reference axle weight of 9,100 kg (maximum legal weight of a dual axle) was used in calculating 'weighted' axles.

For the general truck fleet, weighted axles were calculated for all the truck configurations reported in the Department's classification counts. A recent survey³⁵ indicated that 70% of all trucks carry cargo. It is considered that an average payload weight of 70% of capacity to legal weight limits (i.e. $0.7 \times 0.7 = 49\%$ fleet efficiency) is realistic. The Department provided truck tare weights by axle group. It is estimated that loaded general fleet trucks are equally distributed in both directions and the calculation is done for half of the Truck Average Daily Traffic (TAADT), including both loaded and empty trucks. The final weighted axle count is the weighted sum of both.

The calculation of the weighted number of axles for all the highway truck fleet is given in Exhibit 9.7. The weighted number of axles for grain trucks and the weighted number of axles per tonne of payload is given in Exhibit 9.7.

**Exhibit 9.7: Weighted Number of Axles for All Highway Truck Fleet
(70% Loaded, 30% Empty)**

Configuration	100% Loaded			Tare	70% Payload			Empty	Weighted Average # of Axles
	Max GVW	Payload	Weighted # of Axles		GVW	Payload	Weighted # of Axles		
2-Axle Straight	16,350	8,313	1.80	8,037	13,856	5,819	1.52	0.88	1.33
3-Axle Straight	24,250	12,414	2.66	11,836	20,526	8,690	2.26	1.30	1.97
4-Axle Straight	30,250	18,414	3.43	11,836	24,726	12,890	2.81	1.34	2.37
4-Axle Semi*	31,600	16,632	3.47	14,968	26,610	11,642	2.92	1.64	2.54
5-Axle Semi*	39,500	22,307	4.34	17,193	32,808	15,615	3.61	1.89	3.09
6-Axle Semi	46,500	28,763	5.11	17,737	37,871	20,134	4.16	1.95	3.50
5-Axle Train*	41,900	26,293	4.47	15,607	34,012	18,405	3.63	1.67	3.04
6-Axle Train*	49,800	32,060	5.47	17,740	40,182	22,442	4.42	1.95	3.68
7-Axle A-Train	53,500	33,626	5.93	19,874	43,412	23,538	4.82	2.20	4.03
8-Axle B-Train	62,500	41,942	6.87	20,558	49,917	29,359	5.49	2.26	4.52

* Estimated

³⁵ 2003 Weight Survey. Transportation Policy Branch, Saskatchewan Highways and Transportation. 2004.

**Exhibit 9.8: Weighted Number of Axles for Grain Trucks
(From Grain Haul Audit)**

Weighted Number of Axles (9100 kg = 1 Standard Axle)						Weighted Axles/Tonne Payload		
Configuration	Steering	Single	Tandem	Tridem	Total	Axles/t	Distribution	Weighted
2-Axle Straight	0.80	0.88			1.68	0.23	20.06%	0.0466
3-Axle Straight	0.80		1.95		2.74	0.21	12.00%	0.0251
5-Axle Semi	0.53		3.29		3.82	0.22	26.84%	0.0584
6-Axle Semi	0.53		1.86	2.41	4.79	0.19	14.88%	0.0275
7-Axle A-Train	0.53	1.75	3.53		5.51	0.18	4.29%	0.0078
8-Axle B-Train	0.53		3.57	2.36	6.46	0.17	21.94%	0.0371
Weighted Axles / Tonne Grain								0.2025

9.3.3 Cost Calculation for Haul on TMS and Gravel Surfaced Highways

To establish the cost of haul for all trucks on TMS and gravel pavements, typical costs per axle.km were established for the high, low and mid-range of the design structures given in the Department's Typical Rural Highway Cross Sections, using the average annual life-cycle costs previously calculated. Haul cost per axle.km multiplied by axles per tonne of grain then yielded the cost per tonne.km for grain haul.

The average TAADT, weighted average truck mix and total annual weighted axles were calculated for transitional and sustainable TMS and for gravel roads for both the unrestrained and the corridor traffic assignments. The average cost per weighted axle for all traffic on sustainable TMS and gravel roads is shown in Exhibit 9.9. The high and low range is shown for TMS roads, but since no data could be found to relate maintenance cost to traffic level, the average annual cost was used. The cost per tonne of grain haul was derived using the weighted axle/tonne unit cost previously calculated. The same unit rates were applied for the calculation of costs to municipal roads since not enough base information could be assembled to develop a reliable rate for them as a separate group.

It will be noted that the volume of grain per kilometer increases on both TMS and gravel roads in the corridor system and the unit rates decrease as a result. While the total length of these roads decreases in the corridor system, the remaining grain haul roads are used more intensively.

Exhibit 9.9 Unit Costs for grain Haul on Sustainable TMS and Gravel Roads

Traffic	Sustainable TMS				Gravel			
	Class %	Weighted Axles/ Truck	Trucks/ Day	Weighted Truck Axles/Day	Class %	Weighted Axles/ Truck	Trucks/ Day	Weighted Truck Axles/Day
Average TAADT	32				21			
2A-SU	23.8 %	1.33	3.81	5.07	21.4 %	1.33	2.25	2.99
3A-SU	19.0 %	1.97	3.05	6.00	21.4 %	1.97	2.25	4.43
4A-SU	2.4 %	2.37	0.38	0.90	7.1 %	2.37	0.75	1.78
4A-ST	11.9 %	2.54	1.90	4.84	7.1 %	2.54	0.75	1.91
5A-ST	14.3 %	3.09	2.29	7.06	14.3 %	3.09	1.50	4.64
6A-ST	11.9 %	3.50	1.90	6.66	14.3 %	3.50	1.50	5.25
5A-MT	0.0 %	3.04	0.00	0.00	0.0 %	3.04	0.00	0.00
6A-MT	2.4 %	3.68	0.38	1.40	0.0 %	3.68	0.00	0.00
7A-MT	14.3 %	4.52	2.29	10.33	14.3 %	4.52	1.50	6.78
TOTAL	100.0 %		16.0	42.00	100.0 %		11.0	28.0
Axles/Year (Background Traffic)				15,427				
Axles/Year (Grain Traffic) Unrestrained				3,094				
Total Axles/Year (All Traffic) Unrestrained				18,521				
Axles/Year (Grain Traffic) Corridor				4,219				
Axles/Year (All Traffic) Corridor				19,645				
	Cost/Axle (All Traffic)							
	TMS					Gravel		
	Average	Low	High					
Unrestrained	\$0.3559	\$0.3191	\$0.3927					
Corridor	\$0.3355	\$0.3008	\$0.3702		\$0.1835			
	Cost/Tonne-km (Grain Haul Only)							
	TMS					Gravel		
	Average	Low	High					
Unrestrained	\$0.0721	\$0.0646	\$0.0795					
Corridor	\$0.0679	\$0.0609	\$0.0750		\$0.0378			

Note: Based on all classification counts taken by DHT for these road types.

The estimate of cost of grain haul on transitional TMS roads was done as follows:

- The roads with an AADT > 300 vpd were converted to granular pavement, and ongoing costs were calculated as for granular pavement. In addition, one time upgrading costs of \$175,000/km were charged, amortized over a period of 40 years.

- The roads with an AADT < 300 vpd were converted to gravel surface, and ongoing costs were calculated as for gravel roads. In addition, one time upgrading costs of \$25,000/km were charged, amortized over a period of 40 years.

Upgrading costs were assigned to grain haul in direct proportion to the ratio of grain traffic to all traffic on these roads. Exhibit 9.10 shows the calculation of axles per year for traffic used for the apportioning of costs on transitional TMS roads. Overall, using this procedure, grain is apportioned 15.7% of the upgrading costs of the transitional TMS road sections³⁶. Exhibit 9.11 summarizes the upgrading costs.

Exhibit 9.10: Axles per Year for All Traffic on Transitional TMS Roads

Traffic	Class %	Weighted Axles/Truck	Trucks/Day	Weighted Truck Axles/Day
Average TAADT = 45				
2A-SU	23.2%	1.33	5.22	6.95
3A-SU	17.9%	1.97	4.02	7.91
4A-SU	3.6%	2.37	0.80	1.90
4A-ST	10.7%	2.54	2.41	6.12
5A-ST	16.1%	3.09	3.62	11.18
6A-ST	12.5%	3.50	2.81	9.84
5A-MT	0.0%	3.04	0.00	0.00
6A-MT	1.8%	3.68	0.40	1.48
7A-MT	14.3%	4.52	3.21	14.52
TOTAL			23	60
Axles/yr (Background Traffic)				21,864
Axles/yr (Grain Traffic) Unrestrained				4,506
Total Axles/yr (All Traffic) Unrestrained				26,369
Axles/yr (Grain Traffic) Corridor				5,586
Total Axles/yr (All Traffic) Corridor				27,450

Note: Calculations based on all classification counts taken by DHT for these road sections

³⁶ Compared to the 10% as grains share of overall truck traffic noted for the Primary Highway System only in Exhibit 6.3.

Exhibit 9.11: Calculation of Transitional TMS Conversion Costs

Road Type	Conversion Cost (\$/km)	Length to be Converted (km)	Total Conversion Cost (millions)	Grain Share of Conversion Cost (millions)	Grain Share Cost Annualized* (millions)
Unrestrained Grain Traffic					
TMS>300 VPD	\$175,000	1630	\$285.2	\$44.8	\$2.0
TMS<300 VPD	\$25,000	600	\$15.0	\$2.4	\$0.1
Corridor System Implemented					
TMS>300 VPD	\$175,000	1320	\$231.0	\$36.3	\$1.6
TMS<300 VPD	\$25,000	500	\$12.5	\$2.0	\$0.1

*3% discount rate (long term bond rate minus inflation) over a 40 year time frame

10.0 COST IMPACT OF INCREMENTAL TRAFFIC

10.1 Primary Elevator Grain Haul

The summary of 2004 annual Saskatchewan grain haul costs for unrestrained grain traffic, for grain traffic directed to the corridor system and the corridor system with municipal corridors at primary weights is given in Exhibit 10.1. The traffic included in these costs is limited to the differential increase in haul which can be attributed to the closure of grain delivery points since 1984 but include only the haul in the year 2004.

As can be seen comparing grain haul tonne-km in Exhibit 10.1 for ongoing annual road costs, the *corridor option (with truck weight limits unchanged)* results in about 10% of the traffic being diverted from the TMS and gravel surfaced roads to the AC and granular pavements. Overall, about 78% of the incremental haul occurs on structural pavements, after conversion of the transitional TMS sections. The system concentrates traffic and decreases the total length of roads carrying grain by 22%; however, the total movement by haul vehicles increases by about 5% due to added distance to divert to the corridors.

There is an 11% reduction in the tonne kilometres of grain haul on municipal roads carrying grain in the corridor system, and a corresponding 12% reduction in cost for municipal roads. While the length of these roads decreases in the corridor system, the proportion of grain trucks increases with the additional haul created by the corridor diversion. The net result is a marginal, but not statistically significant, cost increase compared to the base case. Under this option, costs on municipal roads are reduced while costs on provincial roads increase.

The *corridor option with municipal corridors at primary weights* shows about 3% of the traffic being diverted to AC roads, while granular pavements experience a 2% reduction. Overall, about 71% of the incremental traffic occurs on structural pavements. There is an 18% decrease in traffic on TMS roads, while gravel roads experience a 20% increase. The net result of these changes is that traffic increases on municipal roads while decreasing on provincial roads. The total length of roads carrying grain decreases by 20% with the total movement by haul vehicles increased by about 4% due to the added distance to divert to the corridors. This scenario shows a minor, but not a statistically significant, cost savings compared to the base case. Under this option costs increase on municipal roads, while decreasing on provincial roads.

It is noted that there are additional benefits to the Corridor system (with or without primary weights on municipal corridor roads) that could not be captured by the analysis including:

- The corridor system provides a focus for strategic investment for programs aimed at improving roads affected by grain haul, as routes with minimal grain haul are not considered
- By concentrating traffic on specific routes, the corridor system will be a benefit on those occasions when concentrated hauls occur when TMS and gravel roadbeds have high moisture content and hence are very susceptible to damage from even a few loaded trucks. This report deals with system average costs which are not sufficiently detailed to identify these special circumstance costs.
- The corridor system may negate or delay the need for future upgrading some TMS road sections off the system as traffic increases. Site specific analysis beyond the scope of this project would be required to identify any such potential savings.
- Providing an aid in identification of candidate road sections for the Strategic Rural Roads Partnership Program or other similar programs.

Exhibit 10.1: Summary of Incremental Annual Grain Haul Costs in Saskatchewan - Farm to Primary Elevator

Road Type	Provincial			Municipal			Total		
	Length Km	Grain Haul Tonne-Km	Cost	Length Km	Grain Haul Tonne-Km	Cost	Length Km	Grain Haul Tonne-Km	Cost
Scenario 1. Unrestrained Grain Traffic									
AC Pavement	5,500	289,500,000	\$13,000,000	400	6,900,000	\$566,000	5,900	296,400,000	\$13,600,000
Granular Pavement	5,700	159,200,000	\$17,500,000					159,200,000	\$17,500,000
Transitional TMS *									
AADT > 300 vpd	One time conversion cost annualized. Ongoing annual costs assigned to granular (1630 km)								\$2,000,000
AADT < 300 vpd	One time conversion cost annualized. Ongoing annual costs assigned to gravel (600 km)								\$100,000
Sustainable TMS	1,700	26,000,000	\$1,900,000	500	6,100,000	\$443,000	2,200	32,200,000	\$2,300,000
Gravel Surface	1,400	26,100,000	\$1,000,000	13,300	106,400,000	\$4,202,000	14,800	132,400,000	\$5,200,000
Total	14,300	500,800,000	\$33,300,000	14,300	119,400,000	\$5,211,000	28,600	620,200,000	\$40,700,000

Exhibit 10.1 Con't: Summary of Incremental Annual Grain Haul Costs in Saskatchewan - Farm to Primary Elevator

Road Type	Provincial			Municipal			Total		
	Length Km	Grain Haul Tonne-Km	Cost	Length Km	Grain Haul Tonne-Km	Cost	Length Km	Grain Haul Tonne-Km	Cost
Scenario 2. Corridor System Implemented									
AC Pavement									
Corridor	4,900	312,700,000	\$13,481,000	200	4,847,000	\$398,000	5,100	317,600,000	\$13,879,000
Non-Corridor	400	7,500,000	\$474,000	100	1,538,000	\$126,000	500	9,100,000	\$601,000
Total	5,300	320,300,000	\$14,000,000	300	6,400,000	\$524,000	5,600	326,700,000	\$14,500,000
Granular Pavement									
Corridor	4,400	169,900,000	\$17,765,000				4,400	169,900,000	\$17,765,000
Non-Corridor	700	7,500,000	\$859,000				700	7,500,000	\$859,000
Total	5,100	177,400,000	\$18,600,000				5,100	177,400,000	\$18,500,000
Transitional TMS *									
AADT > 300 vpd	One time conversion cost annualized. Ongoing annual costs assigned to granular (1320 km)								
Corridor									\$1,491,000
Non-Corridor									\$339,000
Total									\$1,830,000
AADT < 300 vpd	One time conversion cost annualized. Ongoing annual costs assigned to gravel (500 km)								
Corridor									\$60,000
Non-Corridor									\$44,000
Total									\$105,000
Sustainable TMS									
Corridor	400	15,900,000	\$1,077,000	400	6,527,000	\$443,000	800	22,382,000	\$1,520,000
Non-Corridor	600	6,100,000	\$414,000	40	577,000	\$39,000	700	6,681,000	\$454,000
Total	1,100	22,000,000	\$1,500,000	400	7,100,000	\$482,000	1,500	29,100,000	\$2,000,000
Gravel Surface									
Corridor	500	18,800,000	\$794,000	6,900	79,988,000	\$3,024,000	7,400	98,797,000	\$3,817,000
Non-Corridor	500	5,400,000	\$221,000	2,100	13,861,000	\$524,000	2,600	19,290,000	\$745,000
Total	1,000	24,200,000	\$1,000,000	9,000	93,800,000	\$3,548,000	10,000	118,100,000	\$4,500,000
Total									
Corridor	10,200	517,300,000	\$33,117,000	7,500	91,361,000	\$3,865,000	17,700	608,645,000	\$38,532,000
Non-Corridor	2,200	26,600,000	\$1,968,000	2,200	15,976,000	\$689,000	4,500	42,528,000	\$3,041,000
Total	12,600	543,900,000	\$35,300,000	9,700	107,300,000	\$4,554,000	22,200	651,200,000	\$41,400,000

Exhibit 10.1 Con't: Summary of Incremental Annual Grain Haul Costs in Saskatchewan - Farm to Primary Elevator

Road Type	Provincial			Municipal			Total		
	Length Km	Grain Haul Tonne-Km	Cost	Length Km	Grain Haul Tonne-Km	Cost	Length Km	Grain Haul Tonne-Km	Cost
Scenario 3. Corridor System Implemented – Primary Weight Restrictions on Corridor Municipal Roads									
AC Pavement									
Corridor	4,900	294,300,000	\$12,891,000	200	4,717,000	\$387,000	5,100	299,000,000	\$13,278,000
Non-Corridor	300	5,100,000	\$304,000	100	1,109,000	\$91,000	400	6,200,000	\$395,000
Total	5,200	299,300,000	\$13,200,000	300	5,800,000	\$478,000	5,500	305,200,000	\$13,700,000
Granular Pavement									
Corridor	4,300	148,800,000	\$15,427,000				4,300	148,800,000	\$15,427,000
Non-Corridor	700	6,600,000	\$783,000				700	6,600,000	\$783,000
Total	5,000	155,500,000	\$16,500,000				5,000	155,500,000	\$16,500,000
Transitional TMS *									
AADT > 300 vpd	One time conversion cost annualized. Ongoing annual costs assigned to granular (1370 km)								
Corridor									\$1,475,000
Non-Corridor									\$381,000
Total									\$1,856,000
AADT < 300 vpd	One time conversion cost annualized. Ongoing annual costs assigned to gravel (580 km)								
Corridor									\$63,000
Non-Corridor									\$49,000
Total									\$112,000
Sustainable TMS									
Corridor	400	11,800,000	\$804,000	500	7,886,800	\$536,000	900	19,726,000	\$1,339,000
Non-Corridor	700	6,600,000	\$447,000	0	216,300	\$15,000	700	6,797,000	\$461,000
Total	1,100	18,400,000	\$1,300,000	500	8,100,000	\$550,200	1,600	26,500,000	\$1,800,000
Gravel Surface									
Corridor	500	17,800,000	\$811,000	8,000	123,383,000	\$4,663,900	8,500	141,173,000	\$5,475,000
Non-Corridor	500	5,300,000	\$229,000	1,800	12,057,000	\$455,800	2,300	17,353,000	\$685,000
Total	1,100	23,100,000	\$939,000	9,700	135,400,000	\$5,119,700	10,800	158,500,000	\$6,100,000
Total									
Corridor	10,200	472,700,000	\$29,933,000	8,700	135,987,000	\$5,586,700	18,900	608,719,000	\$37,057,000
Non-Corridor	2,200	23,600,000	\$1,763,000	1,900	13,383,000	\$561,500	4,100	36,988,000	\$2,754,000
Total	12,400	496,300,000	\$31,900,000	10,500	149,400,000	\$6,148,200	22,900	645,700,000	\$40,000,000

10.2 Road Costs for Agro-Processing Traffic

The above costs are for the farm to primary elevator movement of grain. As noted in Chapter 7, there is a large and growing movement of grain to processing locations. This traffic is currently estimated to be 2.0 billion tonne-km per annum.

The available information from the Trimac report on roads travelled by this traffic was used to estimate the road costs associated with this haul, which are provided in Exhibit 10.2. The Trimac report also indicated the 8-axle B-train was used almost exclusively for this haul. As indicated by Exhibit 9.2, this truck type has 51% fewer ESALs per tonne of grain carried compared to the average truck type used to haul grain to primary elevators³⁷. Therefore, for structural pavements, the road impact costs have been reduced by 51% compared to those developed for the farm to elevator movement of grain. Similarly, costs for TMS and gravel roads have been reduced by 15%.

For purposes of this report, the following costs have been assumed: \$0.0044 per tonne-km for primary highways as most of the distance traveled would be on the higher strength asphalt pavements; \$0.0382 for secondary roads representing a blend of costs for TMS, gravel and lower strength asphalt pavements³⁸; and \$0.0321 for gravel roads. A traffic assignment model, which was beyond the resources and time available for this study, would be required to prepare a more rigorous cost estimate.

Exhibit 10.2: Estimated Agro Processing Haul by Road Type

Road Type	Percent Distance Traveled	Total Tonne-km Involved	Unit Cost per Tonne-km (dollars)	Total Annual Cost
Primary highway	68.7 %	1,374,000,000	\$0.0044	\$6,046,000
Secondary highway	22.3 %	446,000,000	\$0.0382	\$17,037,000
Local gravel road	9.0 %	180,000,000	\$0.0321	\$5,778,000
Total	100.0 %	2,000,000,000	n/a	\$28,861,000

10.3 Transport Requirements of Livestock Operations

There have been major increases in livestock production since 1985. These are commonly referred to as Intensive Livestock Operations (ILO). The transport requirements for these operations for feed supply were estimated through a limited telephone survey of the operators. In total, 20 such operations were

³⁷ The average truck used to haul grain has 0.35 ESALs per tonne of grain carried; while the B-Train has 0.17 ESALs per tonne of grain carried ($0.17/0.35 = 0.49$ or 49%). For TMS and gravel roads Exhibit 9.8 indicates the ratio is 0.17/0.20 producing a 15% reduction in costs.

³⁸ The costs used to calculate this average are \$0.0321 for gravel roads (85% of all vehicle gravel costs); \$0.0248 for asphalt concrete (48% of all vehicle cost average cost for 1 to 4 million ESAL range) and \$0.0577 for TMS (85% of all vehicle TMS costs).

contacted. For both animal types, the amount of feed transported per animal by operator fell within a fairly narrow band, indicating consistency between operations. Nevertheless, due to the limited sample size, the results should be taken as indicative only as they are not statistically valid. Truck type used was consistently indicated as a 5-axle tractor trailer. This truck type has virtually the same impact as the typical truck used to haul grain from the farm to the primary elevator and hence the costs developed in Chapter 9 do not need to be adjusted to account for truck type used to haul the feed for these operations.

Operators indicated they tried to source all feed requirements as close to their operations as possible. A few, generally the smaller ones, were able to source all their requirements on site. Most sourced their feed from within a 20 to 30 kilometre radius and nearly all their requirements were met from within a 50 kilometre radius. Some hog producers have some specialty feed requirements which require much longer transport distances, including out-of-province origins.

Exhibit 10.3 summarizes the transport requirements of these operations in terms of tonne-kilometres and provides an estimate of related road costs. As it was not possible to determine the portion of road surface type used for this haul, a blended average to represent all surface types has been used. Obviously, a major portion of this traffic would occur on RM roads, which are largely gravel surfaced³⁹.

Exhibit 10.3: Feed Transport Requirements for Intensive Livestock Operations – Indicative Estimates Only

Operation	Transport Requirements (Tonne-km per annum per animal)	Number of Animals Marketed per Annum*	Total Annual Tonne-km	Road Cost per Tonne-km	Total Annual Road Costs
Hogs	80	1,000,000	80,000,000	\$0.04	\$3,200,000
Cattle	175	400,000	70,000,000	\$0.04	\$2,800,000
Total	n/a	1,400,000	150,000,000	n/a	\$6,000,000

* Incremental since 1985

³⁹ Average based on 90% of traffic on gravel roads at \$0.0378 per tonne-km and 10% on TMS roads at \$0.0679.

10.4 Specialty Crops

Specialty crops are assumed to use the same road types and truck types as the grain haul to primary elevators. This produces a cost of \$0.064 per tonne-kilometre⁴⁰. With an indicative estimated total of 200 million tonne-kilometres per annum, total incremental road costs are estimated at \$12,800,000 per annum.

10.5 Summary of Estimated Road Costs

Overall, grain truck traffic in Saskatchewan has grown exponentially since 1985 when the Western Grain Transportation Act was introduced. In 1985, truck transport of grain was primarily to a network of 588 delivery points. Since that time, a reduced elevator network, increased use of grain at processing plants and rapid growth in intensive livestock operations have resulted in over a 16-fold increase in grain truck haul in the province. This has increased road costs by an estimated \$88.1 million per annum as summarized by Exhibit 10.4⁴¹.

Exhibit 10.4: Summary of Estimated Road Costs Due to Additional Haul

Haul Type	Incremental Tonne-km per Annum	Annual Cost
Farm to Primary Elevator	650,000,000	\$41,400,000
To Agro Processing Facilities	2,000,000,000	\$28,900,000
Feed for ILO's*	150,000,000	\$6,000,000
Specialty crops*	200,000,000	\$12,800,000
Total	3,000,000,000	\$89,100,000

*Numbers are indicative only and to be used with caution

In addition to the above system level costs, there will be specific situations where road improvements will be required that could not be identified by this study. Examples would be where a road would need widening to accommodate the additional truck traffic or bridges would need to be strengthened.

⁴⁰ Cost of \$41.4 million divided by 649.3 million tonne km

⁴¹ This compares favourably with the results of the Parallel Process on Roads Report which identified a cost of \$70 million (in 1999 \$) for a 3 billion tonne kilometre scenario. This would be \$81 million in 2004 dollars (3% inflation rate), for a 10% cost difference between the two approaches.

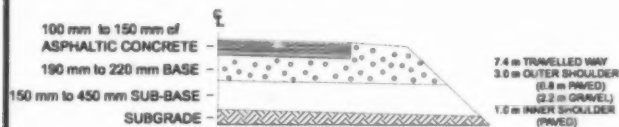
Situations will also occur in and around urban areas where new truck routes, turning lanes or other improvements may have to be developed to accommodate the additional truck traffic. Again, these situations would require specific on site investigations of local conditions to determine if an improvement is necessary.

This means the incremental grain haul noted in this report is a conservative estimate of the increase in truck haul of grain occurring since 1985.

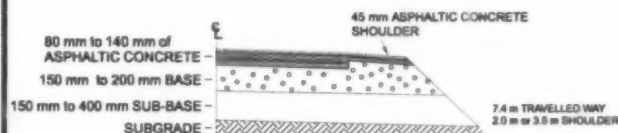
APPENDIX 1: Typical Rural Highway Sections

TYPICAL RURAL HIGHWAY CROSS SECTIONS

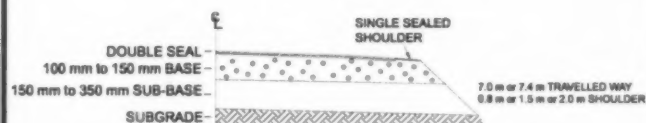
ASPHALT CONCRETE DIVIDED HIGHWAY (outer lane shown)



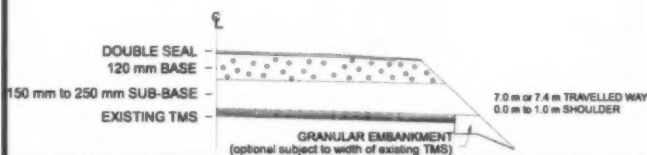
ASPHALT CONCRETE HIGHWAY



GRANULAR PAVEMENT HIGHWAY



GRANULAR STRENGTHENED HIGHWAY



THIN MEMBRANE SURFACE HIGHWAY (No Longer Constructed)



GRAVEL HIGHWAY



TYPICAL RURAL HIGHWAY FACTS (2003 Costs)

Width of Travelled Way:	7.4 m
Width of Each Shoulder:	1.0 m inside and 3.0 m outside
Grading Cost:	\$220,000/km per road
Surfacing Cost:	\$335,000/km per road
Total Cost:	\$555,000/km per road
Surfacing Design Life:	15 to 20 years
Annual Surface Preservation Cost:	\$500 per road
Resurfacing Cost:	\$150,000/km
Annual Life Cycle Cost:	\$19,800/km
Weight Regime:	Primary
Traffic Range:	4 000 to 30 000 vehicles per day

Width of Travelled Way:	7.4 m
Width of Each Shoulder:	2.0 m or 3.0 m
Grading Cost:	\$180,000/km to \$240,000/km
Surfacing Cost:	\$290,000/km to \$350,000/km
Total Cost:	\$470,000/km to \$590,000/km
Surfacing Design Life:	15 to 20 years
Annual Surface Preservation Cost:	\$1,000/km
Resurfacing Cost:	\$155,000 to \$160,000/km
Annual Life Cycle Cost:	\$17,800/km to 20,900/km
Weight Regime:	Primary
Traffic Range:	> 1 200 vehicles per day

Width of Travelled Way:	7.0 m or 7.4 m
Width of Each Shoulder:	0.8 m or 1.5 m or 2.0 m
Grading Cost:	\$120,000/km to \$155,000/km
Surfacing Cost:	\$130,000/km to \$240,000/km
Total Cost:	\$250,000/km to \$395,000/km
Surfacing Design Life:	15 years
Annual Surface Preservation Cost:	\$1,400/km
Resurfacing Cost:	\$110,000/km to \$125,000/km
Annual Life Cycle Cost:	\$14,100 to 18,500/km
Weight Regime:	10 Month Primary or Secondary
Traffic Range:	500 to 1 200 vehicles per day

Width of Travelled Way:	7.0 m or 7.4 m
Width of Each Shoulder:	0.0 m to 1.0 m
Grading Cost:	N/A
Surfacing Cost:	\$150,000/km to \$200,000/km
Total Cost:	\$150,000/km to \$200,000/km
Surfacing Design Life:	15 years
Annual Surface Preservation Cost:	\$1,400/km
Resurfacing Cost:	\$110,000/km to \$125,000/km
Annual Life Cycle Cost:	\$14,100 to 17,600/km
Weight Regime:	Secondary
Traffic Range:	< 700 vehicles per day

Width of Travelled Way:	6.7 m to 7.0 m
Width of Each Shoulder:	0.0 m to 0.8 m
Grading Cost:	\$90,000/km
Surfacing Cost:	\$40,000/km
Total Cost:	\$130,000/km
Surfacing Design Life:	N/A
Annual Surface Preservation Cost:	\$2,500 to \$4,000/km
Resurfacing Cost:	N/A
Annual Life Cycle Cost:	\$9,400/km
Weight Regime:	Secondary
Traffic Range:	< 500 vehicles per day

Width of Travelled Way:	8.6 m to 11.0 m
Width of Each Shoulder:	N/A
Grading Cost:	\$40,000/km to \$140,000/km
Gravel Cost:	\$10,000/km
Total Cost:	\$50,000/km to \$150,000/km
Surfacing Design Life:	N/A
Annual Surface Preservation Cost:	\$1,800/km
Resurfacing Cost:	N/A
Annual Life Cycle Cost:	\$6,000/km
Weight Regime:	Secondary
Traffic Range:	< 500 vehicles per day

- Notes:**
- 1: Construction costs will vary depending on the type of soil, aggregate availability, right of way (land costs), site remoteness and environmental mitigation requirements.
 - 2: Annual surface preservation costs will vary depending annual moisture conditions, condition of existing road and traffic volume.
 - 3: Resurfacing costs will vary depending on the condition of existing surface, strength of subgrade and availability of materials.
 - 4: Life cycle calculation based on a 40 year time period.

APPENDIX 2: Detailed Calculations

Calculation of Pavement 40-Year Life-Cycle Costs

Year	AC Pavement Highway			Granular Pavement Highway			Granular Strengthened Highway		
	Average	Low	High	Average	Low	High	Average	Low	High
0	\$320,000	\$290,000	\$350,000	\$185,000	\$130,000	\$240,000	\$175,000	\$150,000	\$200,000
1	\$250	\$250	\$250	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
2	\$250	\$250	\$250	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
3	\$250	\$250	\$250	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
4	\$250	\$250	\$250	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
5	\$250	\$250	\$250	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
6	\$335	\$335	\$335	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
7	\$420	\$420	\$420	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
8	\$505	\$505	\$505	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
9	\$590	\$590	\$590	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
10	\$675	\$675	\$675	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
11	\$760	\$760	\$760	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
12	\$845	\$845	\$845	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
13	\$930	\$930	\$930	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
14	\$1,015	\$1,015	\$1,015	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
15	\$1,100	\$1,100	\$1,100	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
16	\$157,500	\$155,000	\$160,000	\$117,500	\$110,000	\$125,000	\$117,500	\$110,000	\$125,000
17	\$1,100	\$1,100	\$1,100	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
18	\$1,100	\$1,100	\$1,100	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
19	\$1,100	\$1,100	\$1,100	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
20	\$1,100	\$1,100	\$1,100	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
21	\$1,280	\$1,280	\$1,280	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
22	\$1,460	\$1,460	\$1,460	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
23	\$1,640	\$1,640	\$1,640	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
24	\$1,820	\$1,820	\$1,820	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
25	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
26	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
27	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
28	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
29	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
30	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
31	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
32	\$157,500	\$155,000	\$160,000	\$117,500	\$110,000	\$125,000	\$117,500	\$110,000	\$125,000
33	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
34	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
35	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
36	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
37	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
38	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
39	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
40	\$2,000	\$2,000	\$2,000	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400	\$1,400
40-Year Total	\$684,025	\$649,025	\$719,025	\$473,200	\$403,200	\$543,200	\$463,200	\$423,200	\$503,200
Aver. Ann, \$/yr	\$16,684	\$15,830	\$17,537	\$11,541	\$9,834	\$13,249	\$11,298	\$10,322	\$12,273

ESAL Calculation for All Grain Trucks

Configuration	Tare Weights				
	Steering	Dual	Tandem	Tridem	Total
2-Axle Straight	4,281	3,756			8,037
3-Axle Straight	4,281		7,555		11,836
5-Axle Semi	4,815		12,378		17,193
6-Axle Semi	4,815		6,189	6,733	17,737
7-Axle A-Train	4,815	5,417	9,684		19,915
8-Axle B-Train	4,815		9,684	6,101	20,600

Configuration	Payload Distribution				
	Steering	Dual	Tandem	Tridem	Total
2-Axle Straight	2,969	3,756			7,224
3-Axle Straight	2,969		10,159		13,128
5-Axle Semi			17,537		17,537
6-Axle Semi			11,005	14,888	25,893
7-Axle A-Train		10,552	19,712		30,264
8-Axle B-Train			22,775	15,407	38,182

Configuration	Total Weight					% Cap	Distribution
	Steering	Dual	Tandem	Tridem	Total		
2-Axle Straight	7,250	7,512			15,260	0.93	20.06%
3-Axle Straight	7,250		17,714		24,964	1.03	12.00%
5-Axle Semi	4,815		29,916		34,731	0.88	26.84%
6-Axle Semi	4,815		17,194	21,622	43,630	0.94	14.88%
7-Axle A-Train	4,815	15,969	29,396		50,179	0.96	4.29%
8-Axle B-Train	4,815		32,459	21,508	58,782	0.99	21.94%

Configuration	Total Weight in kN			
	Steering	Dual	Tandem	Tridem
2-Axle Straight	71	74		
3-Axle Straight	71		174	
5-Axle Semi	47		293	
6-Axle Semi	47		169	212
7-Axle A-Train	47	157	288	
8-Axle B-Train	47		318	211

ESALs for Loaded Grain Trucks (Surveyed Loads)							
Configuration	Steering	Dual	Tandem	Tridem	Total	ESALs/Tonne	Incremental ESAL's
2-Axle Straight	4.52	0.73			5.25	0.73	0.15
3-Axle Straight	4.52		2.79		7.31	0.56	0.07
5-Axle Semi	0.94		2.91		3.85	0.22	0.06
6-Axle Semi	0.94		2.49	1.62	5.05	0.19	0.03
7-Axle A-Train	0.94	1.84	2.72		5.50	0.18	0.01
8-Axle B-Train	0.94		3.99	1.59	6.51	0.17	0.04
Wt Average ESALs /Tonne							0.35

ESALs for Grain Trucks						
Configuration	GVW	Payload	ESALs	Distribution	ESAL/Tonne	Incremental ESALs
2-Axle Straight	15,260	7,224	5.25	20.06%	0.73	0.15
3-Axle Straight	24,964	13,128	7.31	12.00%	0.56	0.07
5-Axle Semi	34,731	17,537	3.85	26.84%	0.22	0.06
6-Axle Semi	43,630	25,893	5.05	14.88%	0.19	0.03
7-Axle A-Train	50,179	30,264	5.50	4.29%	0.18	0.01
8-Axle B-Train	58,782	38,182	6.51	21.94%	0.17	0.04
ESALs/Tonne Grain						0.35

Unit Rates for Grain Haul Impact on Structural AC Pavement

glemoal:

Typical Asphalt Concrete Pavement:

Width of Travelled Way.....7.4m
 Width of Each Shoulder.....2.0 m or 3.0 m
 Grading Cost.....\$180,000 to \$240,000 /km
 Surfacing Cost.....\$290,000 to \$350,000 /km
 Total Cost.....\$370,000 to \$590,000 /km
 Surfacing Design Life.....15 to 20 years
 Annual Surface Preservation Cost.....\$1000 /km
 Resurfacing Cost.....\$155,000 to \$160,000 /km
 Annual Life-Cycle cost.....\$17,800 to \$20,000 /km
 Weight Regime.....Primary
 Traffic Range.....>1200 vehicles/day
 - From SHT *Typical Rural Highway Design Standards*

Asphalt Concrete Pavement Cost per Tonne/Km

Highway Traffic Level

Average Low High

Surfacing Cost:	\$320,000	290,000	350000
Resurfacing Cost	\$157,500	155,000	160,000
Design Life (years)	15	15	15
Annual Life-Cycle Cost=	\$16,684	\$15,830	\$17,537

Assume Average CBR = 5.0

Average pavement depth (as per standard)

Asphalt	110 mm	80 mm	130 mm
Base	200 mm	180 mm	200 mm
Sub-base	250 mm	230 mm	280 mm

Design ESAL's (from pavement design chart)	4,000,000	1,000,000	10,000,000
ESAL's per Year	266667	66667	666667
Pavement Cost per ESAL/km	\$0.0626	\$0.2374	\$0.0263
ESAL's per Tonne Payload	0.35	0.35	0.35
Pavement Cost per tonne/km	\$0.0216	\$0.0821	\$0.0091

ESAL's	Cost/T-Km
1,000,000	\$0.0821
4,000,000	\$0.0216
10,000,000	\$0.0091

glemoal:

Use \$.0091 for 10M ESAL and above,
 Straight line interpolation between 10M
 and \$.0216 at 4M ESAL and between
 4M and \$.0821 at 1M ESAL with a
 maximum of \$.0821 below 1M ESAL

Unit Rates for Grain Haul Impact on Granular Pavement

glemoal:

Typical Granular Pavement:
 Width of Travelled Way.....7.0 or 7.4m
 Width of Each Shoulder.....0.5 m or 1.5 m or 2.0 m
 Grading Cost.....\$120,000 to \$165,000 /km
 Surfacing Cost.....\$130,000 to \$240,000 /km
 Total Cost.....\$250,000 to \$305,000 /km
 Surfacing Design Life.....15 years
 Annual Surface Preservation Cost.....\$1400 /km
 Resurfacing Cost.....\$110,000 to \$125,000 /km
 Annual Life-Cycle cost.....\$14,100 to \$18,500 /km
 Weight Regime.....10 mo. Primary or Secondary
 Traffic Range.....500 - 1200 vehicles/day
 - From SHT *Typical Rural Highway Design Standards*

Granular Pavement Cost per Tonne/Km

	Highway Traffic Level						
	Average	Low	High				
Surfacing Cost:	\$185,000	\$130,000	\$240,000				
Resurfacing Cost	\$117,500	\$110,000	\$125,000				
Design Life (years)	15	15	15	15	15	15	15
Annual Life-Cycle Cost=	\$11,541	\$9,834	\$13,249	\$8,560	\$7,720	\$8,200	\$8,440

Assume Average CBR = 5.0

Average pavement depth (as per standard)

	Double Seal						
	125 mm	100 mm	150 mm				
Surface							
Base	125 mm	100 mm	150 mm				
Sub-base	250 mm	150 mm	350 mm				
Design ESAL's (from pavement design chart)	50,000	2,000	800,000	500,000	100,000	200,000	400,000
ESAL's per Year	3333	133	53333	33333	6667	13333	26667
Pavement Cost per ESAL/km	\$3.4624	\$73.7561	\$0.2484	\$0.2568	\$1.1580	\$0.6150	\$0.3165
ESAL's per Tonne Payload	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Pavement Cost per tonne/km	\$1.1969	\$25.4963	\$0.0859	\$0.0888	\$0.4003	\$0.2126	\$0.1094

glemoal:

Use \$0.0859 above 800,000, linear interpolation from \$0.0859 at 800,000 ESAL to \$0.1094 at 400,000 ESAL, linear interpolation from \$0.1094 at 400,000 ESAL to \$0.2126 at 200,000 ESAL and constant at \$0.2126 below 200,000 ESAL

ESAL's	Cost/T-Km
2,000	\$25.4963
50,000	\$1.1969
100,000	\$0.4003
200,000	\$0.2126
400,000	\$0.1094
500,000	\$0.0888
800,000	\$0.0859

Calculation of TMS 20-Year Average Annual Costs

Year	TMS			Gravel Highway		
	Average	Low	High	Average	Low	High
0	\$40,000	\$40,000	\$40,000	\$10,000	\$10,000	\$10,000
1	\$3,250	\$2,500	\$4,000	\$1,800	\$1,800	\$1,800
2	\$3,250	\$2,500	\$4,000	\$1,800	\$1,800	\$1,800
3	\$3,250	\$2,500	\$4,000	\$1,800	\$1,800	\$1,800
4	\$3,250	\$2,500	\$4,000	\$1,800	\$1,800	\$1,800
5	\$3,250	\$2,500	\$4,000	\$1,800	\$1,800	\$1,800
6	\$3,250	\$2,500	\$4,000	\$1,800	\$1,800	\$1,800
7	\$3,250	\$2,500	\$4,000	\$1,800	\$1,800	\$1,800
8	\$3,250	\$2,500	\$4,000	\$1,800	\$1,800	\$1,800
9	\$3,250	\$2,500	\$4,000	\$1,800	\$1,800	\$1,800
10	\$3,250	\$2,500	\$4,000	\$1,800	\$1,800	\$1,800
11				\$1,800	\$1,800	\$1,800
12				\$1,800	\$1,800	\$1,800
13				\$1,800	\$1,800	\$1,800
14				\$1,800	\$1,800	\$1,800
15				\$1,800	\$1,800	\$1,800
Life-Cycle Total	\$72,500	\$65,000	\$80,000	\$37,000	\$37,000	\$37,000
Aver. Ann. \$/yr	\$6,591	\$5,909	\$7,273	\$2,313	\$2,313	\$2,313

A. Weighted No. of Axles/Truck for All Fleet

Weighted Number of Axles (9100kg = 1) (Legal Limits)

Axle Group	Weights		100% Weight Factors	
	Group	Per Axle	Axle	Group
Steering(Tractor)	5,500	5,500	0.60	0.60
Steering Single	7,250	7,250	0.80	0.80
Dual Axle	9,100	9,100	1.00	1.00
Dual Tandem	17,000	8,500	0.93	1.87
Tridem (Semi)	24,000	8,000	0.88	2.64
Tridem (B-Train)	23,000	7,667	0.84	2.53

Weighted Number of Axles per Tonne Payload by Truck Type

Loaded 70% % Empty 30%

Configuration	100% Loaded			Tare	70% Payload			Empty	Weighted Average No. of Axles
	Max GVW	Payload	Weighted No. of Axles		GVW	Payload	Weighted No of Axles	Weighted No of Axles	
2-Axle Straight	16,350	8,313	1.80	8,037	13,856	5,819	1.52	0.88	1.33
3-Axle Straight	24,250	12,414	2.66	11,836	20,526	8,690	2.26	1.30	1.97
4-Axle Straight	30,250	18,414	3.43	11,836	24,726	12,890	2.81	1.34	2.37
4-Axle Semi*	31,600	16,632	3.47	14,968	26,610	11,642	2.92	1.64	2.54
5-Axle Semi*	39,500	22,307	4.34	17,193	32,808	15,615	3.61	1.89	3.09
6-Axle Semi	46,500	28,763	5.11	17,737	37,871	20,134	4.16	1.95	3.50
5-Axle Train*	41,900	26,293	4.47	15,607	34,012	18,405	3.63	1.67	3.04
6-Axle Train*	49,800	32,060	5.47	17,740	40,182	22,442	4.42	1.95	3.68
7-Axle A-Train	53,500	33,626	5.93	19,874	43,412	23,538	4.82	2.20	4.03
8-Axle B-Train	62,500	41,942	6.87	20,558	49,917	29,359	5.49	2.26	4.52

*Estimated

B. Weighted No. of Axles for Grain Trucks Only

Calculation of ESAL's from 2003-2004 Weight Surveys

Total	Bins 4-7			Bins 8-10		
Empty - Tare	Sample	Weight	ESAL	Sample	Weight	ESAL
Steering Single	658	4,281	1.02	1,623	4,815	1.03
Single	255	3,756	0.11	79	3,964	0.10
Tandem	428	7,555	0.20	2,375	6,189	0.08
Tridem				841	6,733	0.04
Total	Bins 11-13			Bins 4-13		
Empty - Tare	Sample	Weight	ESAL	Sample	Weight	ESAL
Steering Single	810	4,774	0.95	3,091	4,690	1.01
Single	93	2,708	0.03	427	3,566	0.09
Tandem	1,636	4,842	0.03	4,439	5,824	0.08
Tridem	746	6,101	0.02	1,587	6,436	0.03

Tare Weights					
Configuration	Steering	Single	Tandem	Tridem	Total
2-Axle Straight	4,281	3,756			8,037
3-Axle Straight	4,281		7,555		11,836
5-Axle Semi	4,815		12,378		17,193
6-Axle Semi	4,815		6,189	6,733	17,737
7-Axle A-Train	4,815	5,417	9,684		19,915
8-Axle B-Train	4,815		9,684	6,101	20,600

Payload Distribution					
Configuration	Steering	Single	Tandem	Tridem	Total
2-Axle Straight	2,969	4,255			7,224
3-Axle Straight	2,969		10,159		13,128
5-Axle Semi			17,537		17,537
6-Axle Semi			10,736	15,157	25,892
7-Axle A-Train		10,552	19,712		30,264
8-Axle B-Train			22,775	15,407	38,182

Total Weight					
Configuration	Steering	Single	Tandem	Tridem	Total
2-Axle Straight	7,250	8,010			15,260
3-Axle Straight	7,250		17,714		24,964
5-Axle Semi	4,815		29,916		34,731
6-Axle Semi	4,815		16,925	21,890	43,630
7-Axle A-Train	4,815	15,968	29,396		50,179
8-Axle B-Train	4,815		32,459	21,507	58,781

Weighted Number of Axles for Grain Trucks (From Grain haul Audit)

Weighted Number of Axles (9100 kg =1 Standard Axle)						Weighted Axles/Tonne Payload		
Configuration	Steering	Single	Tandem	Tridem	Total	Axles/t	Distribution	Weighted
2-Axle Straight	0.80	0.88			1.68	0.23	20.06%	0.0466
3-Axle Straight	0.30		1.95		2.74	0.21	12.00%	0.0251
5-Axle Semi	0.53		3.29		3.82	0.22	26.84%	0.0584
6-Axle Semi	0.53		1.86	2.41	4.79	0.19	14.88%	0.0275
7-Axle A-Train	0.53	1.75	3.23	0.00	5.51	0.18	4.29%	0.0078
8-Axle B-Train	0.53		3.57	2.36	6.46	0.17	21.94%	0.0371
						Weighted Axles/Tonne Payload		0.2025

glenoat:	glenoat:
Typical Thin Membrane Surface Highway:	Typical Gravel Surface Highway:
Width of Travelled Way.....6.7 to 7.0m	Width of Travelled Way.....6.6 to 11.0m
Width of Each Shoulder.....0.0 m or 0.5 m	Width of Each Shoulder.....n/a
Grading Cost.....\$90,000 /km	Grading Cost.....\$40,000 /km to \$140,000/km
Surfacing Cost.....\$40,000 /km	Surfacing Cost.....\$10,000 /km
Total Cost.....\$130,000 /km	Total Cost.....\$50,000 /km to \$150,000/km
Surfacing Design Life.....n/a	Surfacing Design Life.....n/a
Annual Surface Preservation Cost.....\$2,500/km to \$4,000/km	Annual Surface Preservation Cost.....\$1,800/km
Resurfacing Cost.....n/a	Resurfacing Cost.....n/a
Annual Life-Cycle cost.....\$9,400/km	Annual Life-Cycle cost.....\$6000/km
Weight Regime.....Secondary	Weight Regime.....Secondary
Traffic Range.....<500 vehicles/day	Traffic Range.....<500 vehicles/day
- From SHT Typical Rural Highway Design Standards	- From SHT Typical Rural Highway Design Standards

Calculation of Unit Costs for Haul on Sustainable TMS and Gravel Surface Roads

Traffic	Class %	Sustainable TMS			Class %	Gravel		
		Weighted Axles/Truck	Trucks /Day	Weighted Truck Axles/Day		Weighted Axles/Truck	Trucks /Day	Weighted Truck Axles/Day
Average TAADT		32				21		
2A-SU	23.8%	1.33	3.81	5.07	21.4%	1.33	2.25	2.99
3A-SU	19.0%	1.97	3.05	6.00	21.4%	1.97	2.25	4.43
4A-SU	2.4%	2.37	0.38	0.90	7.1%	2.37	0.75	1.78
4A-ST	11.9%	2.54	1.90	4.84	7.1%	2.54	0.75	1.91
5A-ST	14.3%	3.09	2.29	7.06	14.3%	3.09	1.50	4.64
6A-ST	11.9%	3.50	1.90	6.66	14.3%	3.50	1.50	5.25
5A-MT	0.0%	3.04	0.00	0.00	0.0%	3.04	0.00	0.00
6A-MT	2.4%	3.68	0.38	1.40	0.0%	3.68	0.00	0.00
7A-MT	14.3%	4.52	2.29	10.33	14.3%	4.52	1.50	6.78
TOTAL	100.00%		16	42	100.00%		11	28
Axles/Yr (Background Traffic)				15,427				10,134
Axles/Yr (Grain Traffic) Unrestrained				3,094				1,723
Total Axles/Yr (All Traffic) Unrestrained				18,521				11,857
Axles/Yr (Grain Traffic) Corridor				4,219				2,268
Total Axles/Yr (All Traffic) Corridor				19,645				12,462
Cost/Axle (All Traffic)								
Unrestrained Scenario Corridor Scenario	TMS				Gravel			
	Average	Low	High					
	\$0.3559	\$0.3191	\$0.3927				\$0.1950	
	\$0.3355	\$0.3008	\$0.3702				\$0.1865	
Unrestrained Scenario Corridor Scenario	Cost/Tonne-Km (Grain-Haul Only)				Gravel			
	Average	Low	High					
	\$0.0721	\$0.0646	\$0.0795				\$0.0395	
	\$0.0679	\$0.0609	\$0.0750				\$0.0378	

Sustainable TMS Roads

Scenario	Length	Tonne-Km
Unrestrained	1,704	26,037,504
Corridor	1,054	21,948,792

Gravel

Scenario	Length	Tonne-Km
Unrestrained	14,136	120,241,360
Corridor	9,448	105,793,326

ghmost:
 Typical Granular Strengthened Highway:
 Width of Travelled Way 7.0 to 7.4 m
 Width of Each Shoulder 0.0 to 1.0 m
 Grading Cost n/a
 Surfacing Cost \$150,000/km to \$200,000/km
 Total Cost \$150,000/km to \$200,000/km
 Surfacing Design Life n/a
 Annual Surface Preservation Cost \$2,500/km to \$4,000/km
 Resurfacing Cost \$110,000/km to \$125,000/km
 Annual Life-Cycle cost \$14,000/km to \$17,000/km
 Weight Regime Secondary
 Traffic Range <700 vehicles/day
 - From SHT Typical Rural Highway Design Standards

TMS Upgrading Rates
TMS to Granular Strengthened - \$175,000/km
TMS to Gravel - \$25,000/km

All Provincial TMS Roads With Data				All Provincial TMS Transitional Roads With Data				All Provincial TMS Sustainable Roads With Data				All Provincial Gravel Roads With Data			
Total Length 6521.17				Total Length 3678				Total Length 2842				Total Length 6477			
AADT 377				AADT 430				AADT 310				AADT 74			
Config	Average	%AADT	Class %	Config	Average	%AADT	Class %	Config	Average	%AADT	Class %	Config	Average	%AADT	Class %
2ASU	11.65	3.09%	23.14%	2ASU	13	3.02%	23.21%	2ASU	10	3.23%	23.81%	2ASU	3	4.05%	21.43%
3ASU	8.99	2.38%	17.86%	3ASU	10	2.33%	17.86%	3ASU	8	2.58%	19.05%	3ASU	3	4.05%	21.43%
4ASU	1.88	0.50%	3.73%	4ASU	2	0.47%	3.57%	4ASU	1	0.32%	2.38%	4ASU	1	1.35%	7.14%
4AST	5.54	1.47%	11.00%	4AST	6	1.40%	10.71%	4AST	5	1.61%	11.90%	4AST	1	1.35%	7.14%
5AST	7.73	2.05%	15.35%	5AST	9	2.09%	16.07%	5AST	6	1.94%	14.29%	5AST	2	2.70%	14.29%
6AST	5.91	1.57%	11.74%	6AST	7	1.63%	12.50%	6AST	5	1.61%	11.90%	6AST	2	2.70%	14.29%
5AMT	0	0.00%	0.00%	5AMT	0	0.00%	0.00%	5AMT	0	0.00%	0.00%	5AMT	0	0.00%	0.00%
6AMT	1.11	0.29%	2.20%	6AMT	1	0.23%	1.79%	6AMT	1	0.32%	2.38%	6AMT	0	0.00%	0.00%
7AMT	7.54	2.00%	14.98%	7AMT	8	1.86%	14.29%	7AMT	6	1.94%	14.29%	7AMT	2	2.70%	14.29%
TAADT	50.35	13.36%	100.00%	TAADT	56	13.02%	100.00%	TAADT	42	13.55%	100.00%	TAADT	14	18.92%	100.00%

Axes per Year for All Traffic on Transitional TMS Roads

Traffic	Class %	Weighted Axles/Truck	Trucks /Day	Weighted Truck Axles/Day
Average TADT			45	
2A-SU	23.2%	1.33	5.22	6.95
3A-SU	17.9%	1.97	4.02	7.91
4A-SU	3.6%	2.37	0.80	1.90
4A-ST	10.7%	2.54	2.41	6.12
5A-ST	16.1%	3.09	3.62	11.18
6A-ST	12.5%	3.50	2.81	9.84
5A-MT	0.0%	3.04	0.00	0.00
6A-MT	1.8%	3.68	0.40	1.48
7A-MT	14.3%	4.52	3.21	14.52
TOTAL	100.00%		23	60
Axles/Yr (Background Traffic)				21,864
Axles/Yr (Grain Traffic) Unrestrained				4,506
Total Axles/Yr (All Traffic) Unrestrained				26,369
Axles/Yr (Grain Traffic) Corridor				5,586
Total Axles/Yr (All Traffic) Corridor				27,450

TMS Transitional		
Scenario	Length	Tonne-km
Unrestrained	2,308	51,352,988
Corridor	1,897	52,317,256

**APPENDIX 3: Analysis of Corridor System with
Municipal Roads at Primary Weights**

Exhibit 3.A: Incremental Grain Haul Assignment for Scenario 3 (Northeast Saskatchewan)

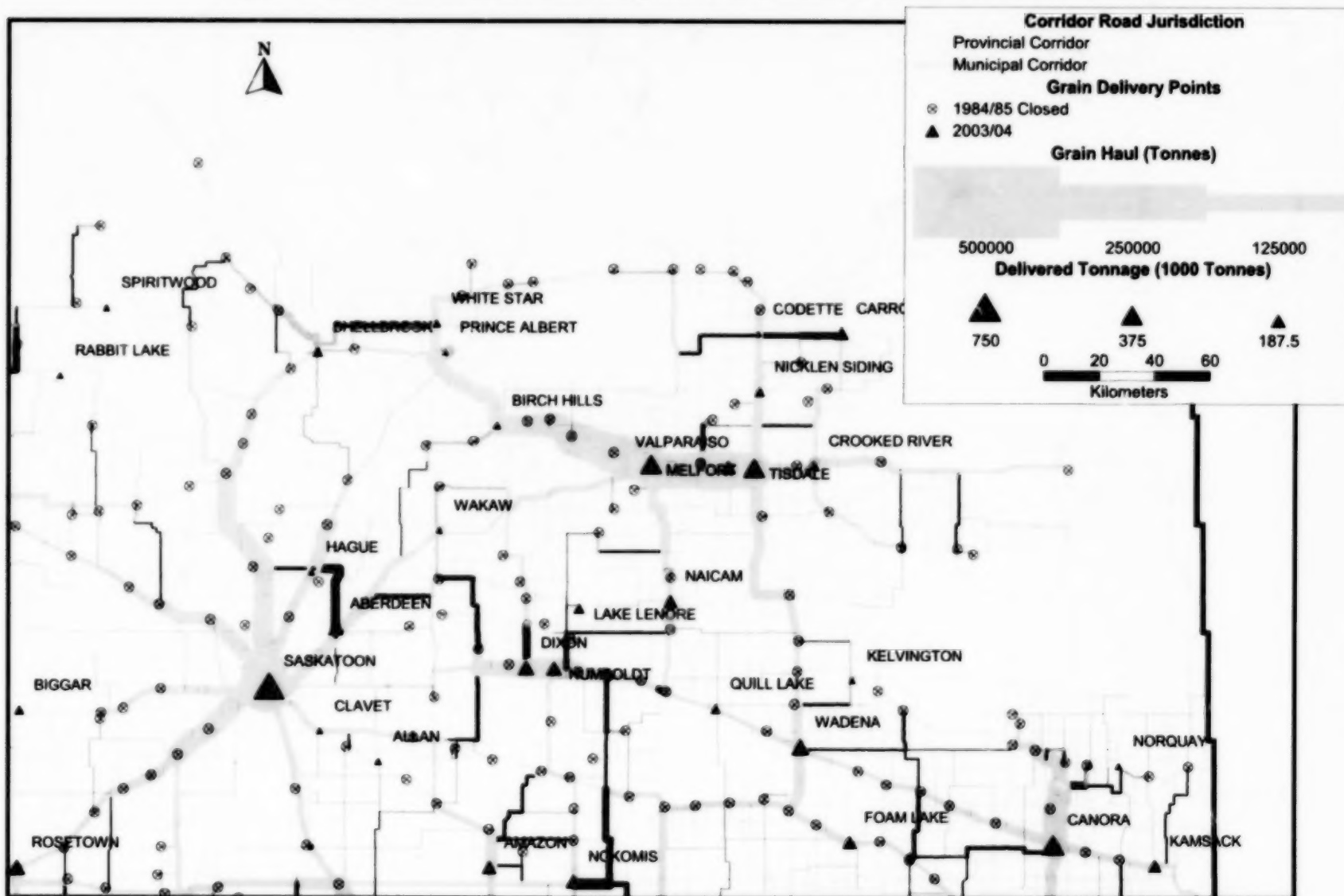


Exhibit 3.B: Incremental Grain Haul Assignment for Scenario 3 (Southeast Saskatchewan)

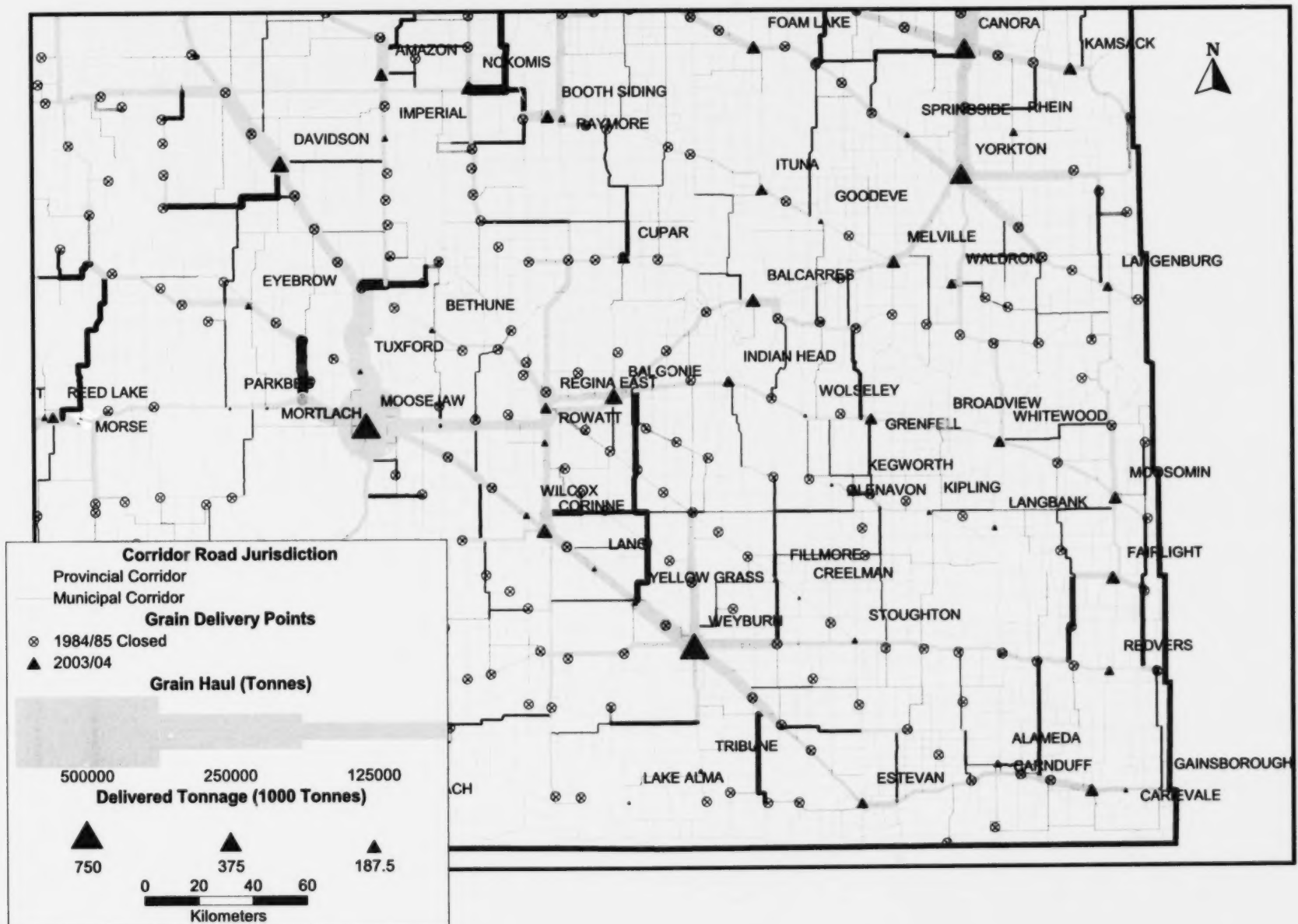


Exhibit 3.C: Incremental Grain Haul Assignment for Scenario 3 (Southwest Saskatchewan)

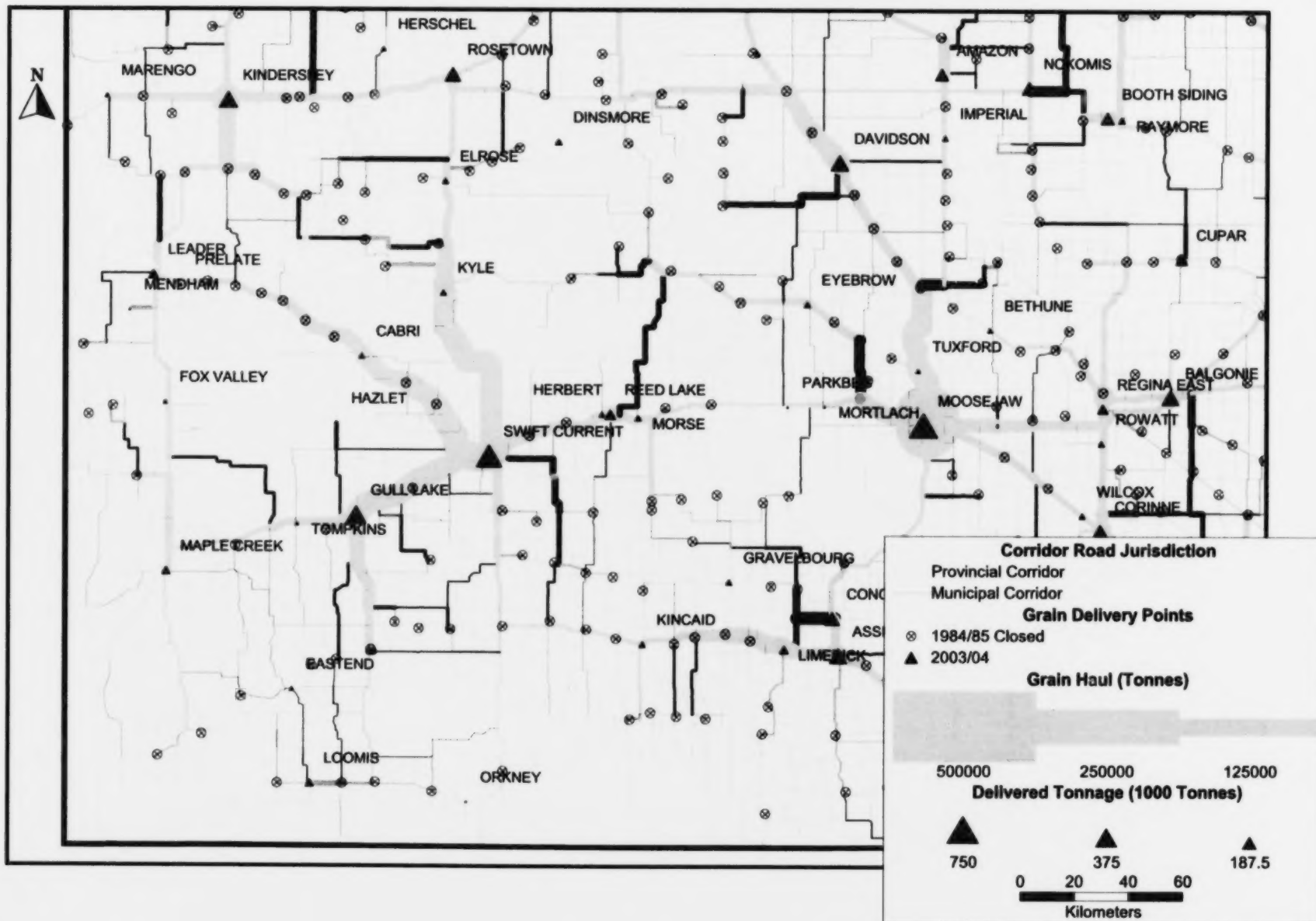


Exhibit 3.D: Incremental Grain Haul Assignment for Scenario 3 (Northwest Saskatchewan)

